WATER AS A FOREST PRODUCT

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INTRODUCTION

Water is man's most precious commodity. In New Zealand, the water resources have been regarded as limitless, but it is becoming increasingly clear that they are not, and, further, some of our waters are becoming unfit to drink because pollution of water supplies is becoming more common in most parts of the country. As demands for water grow, so preservation of the quality of water becomes more important, and this is one of the chief aims of the Water and Soil Conservation Act, 1967. A large number of regulatory bodies has been set up under this act — Water and Soil Conservation Authority, Soils and Rivers Control Council, Pollution Advisory Council, Water Allocation Council and 25 Regional Water Boards — to see that the provisions of the Act are applied. However, the most important consideration is the condition of the catchments supplying storage reservoirs. Many studies have confirmed that land clothed in forests produces significantly lower total yields of water than land in grass, but total yield is only one factor to consider. Regulation of yield throughout the year is another and, one of the most important, the question of nutrient enrichment. It is generally considered that forests have the greatest potential for overcoming this problem, but research is needed to confirm this. Indeed, a great deal of research into many aspects of water supply is needed to determine the most practical solutions to current problems.

NATIONAL WATER USE

The present position with domestic water supplies is as follows:

- 55% of the population depend on surface catchments.
- 30% receive unchlorinated water.
- 24% receive water with a pH factor outside the acceptable range.
- 3% receive water with iron contamination problems.

Guidelines for the quality of domestic water supplies have been laid down by the World Health Organization. Industries, too, must have water of a high standard; steam-raising water must be free of organic salts; water for food processing must

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meet specific requirements in addition to expected potability. In fact, the requirements of many wet industries are so specialized and in excess of normally accepted standards that re-treatment is necessary to meet them. Even for use in energy conversion high quality water is essential.

In 1969, domestic consumption from public water supplies was some 230 000 million litres, while industry used over 270 000 million litres. In addition, 500 000 million litres was used for generation of hydro-electricity, while increasing demands for irrigation water are being met in the South Island. Moreover, the agricultural community generally is seeking better quality water for both domestic and farm use. New Zealand is, in fact, reaching the point where less satisfactory sources of water will have to be used, and this will entail more complicated treatments to meet the consumer's needs.

The whole field of water use and conservation is covered by the 1967 Act, the aim of which is to promote a national policy for natural waters and to make proper provision for the conservation, allocation, use and quality of such waters. It also provides for the promotion of soil conservation and flood prevention; for the control of multiple uses of water and land drainage; for provision of water supplies to primary and secondary industries and to local authorities, and for fisheries and wildlife habitats; and for the oversight of all recreational uses of water.

WATER QUALITY

This is currently the most important aspect of water supply, and a critical factor is often the condition of the catchment areas. The first problem in these areas is erosion, which has a major effect in reducing quality and increasing turbidity. For example, with the present normal sediment load, there are no fish in the Waipaoa River in Poverty Bay, and if there was an industrial plant using 45 million litres a day from this river, its filtration plant would have to remove $2\frac{1}{4}$ tonnes of silt daily to make the water usable. There are many other areas in New Zealand where the principal problem is erosion, which in turn is a product of land mismanagement. The consequences are far-reaching; sediment gradually depletes the capacity of reservoirs, increases the cost of treatment, affects the oxygen status in streams and lakes, damages power turbines and pumping equipment, and obliterates fish spawning grounds. Experiments in the U.S.A. have shown that sediment load increases with the increasing intensity of land use, and the effects of good land management on reducing sediment yield have been one of the most successful aspects of small catchment research. The need to improve patterns of land use and to plan for long-term stability is thus obvious. New Zealand has, in the main, a forest climate. The original forests were highly complex and efficient at controlling infiltration and run-off. In many places, catchments should be reforested, and it is probable that exotic species should often be used, with a protective and a productive role, both for conservation and for sound economic reasons.

The second major problem is nutrient enrichment. Enormous quantities of fertilizer are applied annually to grassland, much of which reaches water courses by surface run-off and in drainage water; this portion is thus wasted as far as agricultural production is concerned. This problem has been particularly acute in 1972-3 owing to a huge upturn in farm incomes, and because of drought conditions. The cost of removing salts from water can be high, and there is need for detailed study of the whole field of fertilizer application to minimize the leached portion and so to ensure that the quantities reaching water supplies are markedly reduced. This in turn should improve the economics of fertilizer application for the farmer. Nutrient enrichment is also the result of the discharge of domestic, industrial, farm and miscellaneous protein-rich wastes into natural waters.

The result of these factors is eutrophication of waters, often to a point where remedial action is impossible. The results of this are: growth of water weeds, creating problems for hydro-electric plants and domestic boat owners; reduction in fish populations; excessive hatches of lake fly; "summer itch" affecting those wishing to find recreation; and the loss of aesthetic appeal. Eutrophication has been attributed to an increase in phosphate and nitrates, but recent studies indicate that the amount of soluble iron may be an even more important factor. In any case, the process seems to be linked with the increase of intensively farmed land in the catchment areas, and therefore successful control must be sought by way of changing land management practices on these areas.

Professor V. J. Chapman, in addressing the National Water Resources Conference in 1970, referred to the problem of eutrophication in North Island lakes by saying: "What has happened to the Rotorua and Waikato hydro lakes has aroused great concern, and in the case of Lake Taupo, which is at present reasonably oligotrophic (low in nutrients) it is now proposed to have reserves all around the lake. The vegetation in these reserves, probably mostly trees, will trap surplus fertilizer being washed off adjacent aerial-topdressed farmlands. It is probably too late to take this kind of action for Lakes Rotorua, Rotoiti and even Tarawera. The remaining lakes, however, should have a natural vegetation belt around their shores, and the clearing of bush to the water's edge should be prohibited."

There is a need for review of land subsidy rates so that more land can be protected. Further, it seems that afforestation of catchment lands has the greatest potential for the prevention of nutrient enrichment. Few plants can match the growth rate, and consequently the nutrient uptake, of radiata pine, and the use of this species for this purpose, especially where it can be harvested as a crop, has much to commend it.

WATER YIELDS

Misconceptions about the relationship between forests and water yield are common. It is sometimes claimed that forests increase rainfall, but there is little evidence to support this belief. On the other hand, transpiration from forest should be greater than from lower forms of vegetative cover, but most evidence is inconclusive because this factor is complicated by a large number of variables. However, it is clear that water yield is strongly influenced by the cover on catchment areas. Most studies in the U.S.A. show an increasing water yield with increasing removal of forest. From a comprehensive review of 39 studies, Hibbert (1967) concluded that a reduction in forest cover generally increased yield, while afforestation of sparsely-covered land reduced it.

Perhaps the most conclusive evidence in New Zealand is provided by studies carried out by the Ministry of Works on the 1450 km^2 of catchments lying between the Lake Taupo outlet and Karapiro in 1950 and the late 1960s. The first study showed flood flows of 480 m^3/sec and this estimate was used for the construction of the Waikato River hydro-electric plants. The second study indicated a major flood flow of 1350 m^3/sec— an increase of 180%, and this was attributed largely to the fact that some 520 km^2 had been converted from scrubland to grassland farms in the interim.

Conclusions from a review of literature prepared on this subject by I. Barton were:

- While it is likely that increased vegetation height does have an effect on water yield, there is insufficient evidence to show what the effect is.
- Water yield is probably affected by the relative mass of vegetation rather than the species, although here also the evidence is inconclusive.
- The removal of at least 20% of the vegetation from an area will increase water yields. Conversely, replacing scrub or grass with trees eventually decreases yields.

When afforestation of catchment areas is considered, water yield may become the limiting factor. Where there is ample rainfall and yield is greater than projected future demands, there is little doubt that afforestation of watersheds is desirable. But where precipitation is considered marginal, even though afforestation may markedly improve water quality, it may also lower yields to an unacceptable degree.

With these considerations in mind, the Auckland Regional Authority has been establishing species trials since 1961, including both native and exotic trees. The short period of these studies is insufficient to allow a proper evaluation of the potentialities of these species for this role but several, especially *Acacia melanoxylon, Cryptomeria japonica* and *Cupressus lusitanica,* already show promise. The major plantings have been radiata pine, which appears to be the best economic proposition. However, some other tree crops could give a better economic return because of high unit value, and if radiata pine uses more water than other species it may become necessary to use less demanding crops in future.

It is apparent that afforestation will have a most important part to play in catchment areas in many parts of New Zealand.

MULTIPLE USE OF WATER — THE NEW PLYMOUTH EXPERIENCE

New Plymouth faced a serious power shortage when electric trams were introduced in 1915, and ambitious plans were drawn up for an artificial lake to supply a new hydro-electric power station. Lake Mangamahoe was eventually completed in 1931, with an area of some 30 hectares and a storage capacity of some 160 million litres of water, but a much reduced draw-off capacity compared with the original proposals. Water is supplied from a confined catchment, mainly from the slopes of Mount Egmont and open farmland, and passes through a settling pond before entering the lake. The power station's output varies between 15 and 18 million kWh annually, which is sufficient for 8% of the power in the supply area. By generating on the peak load there is a saving of $23.50 for every kilowatt generated, and the annual net savings to consumers, who number some 44 500, is about $90 000.

The city water supply has also been provided from Lake Mangamahoe for the last 40 years. A modern water treatment plant was completed in 1971 capable of treating 72 million litres a day. It now serves a population of some 38 000, with an annual consumption of 4 878 million litres for domestic use and 3 253 million litres for industry. Water treated and delivered to the district reservoirs cost 12 cents per 4 500 litres and the supply for 1972 was valued at $216 000.

Tree planting began in 1924 when a number of species were planted with the object of being self-sufficient in power poles. The main planting was with eucalypts but they grew to too large a size and it was considered that their rapid growth would result in poor lasting qualities. Many other species were tried over the years, including *Cryptomeria japonica, Cedrus atlantica, Picea sitchensis, Pseudotsuga menziesii* and *Cupressus macrocarpa*. The most suitable species, both for power pole production and for preventing run-off from the steep hillsides surrounding the lake, was found to be macrocarpa, and fairly substantial plantings were made. However, by the time these trees were of a suitable size for poles, the use of concrete poles had become generally accepted, and the trees were left to grow.

Radiata pine was first planted in 1931 as a shelterbelt species around the perimeter ridges to protect the other plantings, but by 1940 it was decided to form a radiata plantation over 160 hectares because the soils had proved unsuitable for successful farming, and regular plantings continued through the next decade. The only problem arising from planting conifers has been due to the accumulation of resin in the fine sediment on the lake floor. If peak water draw-off coincides with peak loading power generation, increased water movement disturbs this sediment, and this causes treatment problems and also gives the water an unpleasant taste. It is therefore necessary to avoid felling trees into the lake, and to replace conifers near the shore with permanent amenity plantings.

It was necessary to construct vehicle access to the western side of the lake to service intake screens to the generation supply tunnel. This provided access for the general public, whose use of the area has increased over the years. There is a magnificent view of Mount Egmont from the southern end of the lake which is enhanced by the early plantings of eucalypts and macrocarpa. The lake also provided a perfect habitat for waterfowl and the whole forest area was at an early stage declared a Wild Life Refuge. In 1968 a group of 32 black teal was liberated and today a flock of some 400 of these distinctive fowl is a notable feature of the environment. The Acclimatisation Society has made an annual liberation of trout fingerlings for many years and the lake is thus also a popular fishing haunt. Lake Mangamahoe has rightly become a highly popular area for recreation.

It is clear that recreation should be a primary objective when planning resource development, especially where there is a conjunction of water and forest. New Zealand society in 25 years will have leisure, wealth and education and will not look kindly on shortsighted developments which have not taken this into account.

CONCLUSION

Land management is a crucial factor in preserving water resources and, since water is a limited resource, it will require good management practices including promotion of methods to reduce loss and wasteful use. Foremost in all future considerations of water development will be the principle of multiple use. For this to be effective, co-ordination and co-operation of all water users will be required to ensure that the maximum benefits are obtained from any development.

The whole concept of present agricultural topdressing programmes should be investigated both for economic reasons and to mitigate the problems of nutrient enrichment of waters.

There is need for an urgent review of subsidy rates so that more land can be protected for posterity, and there is a need for greater emphasis on the planting of protective and productive forests for sound economic reasons as well as for conservation purposes.

REFERENCE

Hibbert, A. R., 1967. Forest treatment effects on water yield. *Proc. int. Symp. For. Hydrology.* Pennsylvania State University.