EFFECTS OF FOREST DISEASES AND PLANTATIONS

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Abstract

Local and overseas studies on the effect of plantation establishment and forest diseases on hydrological balance and water quality are reviewed. The conclusions are related to the local situation, in particular the accumulation of salt in the landscape, and compared with observed facts within the region. Finally, the implication of these conclusions on forest management are considered.

INTRODUCTION

I wish to stress right at the beginning that my evaluation of the hydrological impact of such massive alteration of vegetation as die-back disease and plantation establishment is based on a very mixed collection of studies and observations. Perhaps this is not surprising. We are dealing with perturbations, the amplitude of which probably spans several decades. To be reasonably sure about any conclusions regarding these perturbations, one would need a set of paired catchments, calibrated for a few years prior to the commencement of the perturbations. One would need to follow the impact of the perturbations throughout the entire cycle leading up to the re-establishment of a new equilibrium. Such studies have now been initiated, at least with respect to plantation establishment, but are still at the calibration stage.

That being the case, an alternative approach is necessary. As I lack the necessary skill for mathematical modelling, the best that I can do is to review all available information and string it together into a plausible story. The available information can be put into the following categories.

(a) experimental evidence relevant both topically and geographically,

(b) experimental evidence relevant topically, but from a different geographic region,

(c) other local evidence that has a bearing on the topic.

RELEVANT LOCAL STUDIES

The only study that fits into the first category is the cooperative hydrological investigation of plantation establishment by Forests Department and Public Works Department in eastern Mundaring. Its most serious limitation is that it is only just starting, but ultimately it will replace speculations, such as this one, with factual knowledge. Another cooperative venture, combining the two organizations already mentioned and CSIRO in a study of agro-forestry, is commencing this year in Upper Helena catchment. Both studies will only yield information on the eastern, low rainfall zone, which is the most critical one.

RELEVANT STUDIES IN OTHER REGIONS

It is the second category of information that is probably in best supply. There are quite a number of overseas and Eastern States studies - Zahner (1954), Metz and Douglass (1959), Hewlett and Hibbert (1961), Hallin (1967), Bell and Gatenby (1969), Troendle (1970), Herring (1970), Colville and Holmes (1972), Smith *et al.* (1973) - that deal with hydrological characteristics of broadleaved and coniferous forests and plantations.

On the basis of these one can make the following generalizations:

(a) removal of existing cover leads to reduction in evapotranspiration and increase in either ground water storage or yield,

(b) coniferous plantations have high rates of interception and evapotranspiration, and in winter rainfall climate can ultimately utilize a high proportion of incoming rainfall,

(c) conversion of broad leaved forest to coniferous plantation can therefore increase yield initially, but ultimately the yield will fall down to, or below, the original level.

THE EFFECT OF COASTAL PLANTATION ON THE HYDROLOGICAL BALANCE.

Similar observations are available locally, from the coastal plain. Hopkins (pers. comm.) recorded rise in ground water table following destruction of a pine stand by fire, and the subsequent return toward original level as a new pine stand developed. He also studied the use of water by newly planted pines and concluded that by the age of 3 years the pines had an extensive root system and were utilizing high proportion of the incoming rainfall. Havel (1968) observed that young dense pine plantations had rates of water utilization well in excess of eucalypt-banksia woodland which they replaced, so much so that in years of below average rainfall readjustment occurred through drought deaths. Butcher and Havel (1975) were able to relate the rate of water withdrawal and replenishment to the density of pine stands, and, by experimental reduction of the density through thinning, established an equilibrium resembling that of the native woodland.

Butcher (1976) quantified these observations, and concluded that a dense pine stand intercepted 26 per cent of the incoming rainfall and transpired the remainder during the dry summer. In years of above average rainfall, higher rate of water use and higher pine increment were observed in dense stands, whereas in heavily thinned stands higher rainfall resulted in higher through-put of water to underground aquifers.

THE EFFECT OF DIEBACK DISEASE ON HYDROLOGICAL BALANCE

Virtually no experimental evidence is available, locally or from overseas, on the impact of a major disease such as the jarrah dieback. Although the hydrological impact of the disease is poorly documented, this deficiency can be partly compensated for by reference to other serious disruptions of vegetation. The ultimate effect of the disease is to reduce a tall two storied forest with shrubby ground cover to a savannah woodland with irregular, low open overstorey and ground cover of sedges. This is rather similar to the conversion of a forest to a parkland clearing with ground cover of grasses, except in so far that sedges are perennial, whereas grasses are only annual. This type of perturbation of vegetation cover, in particular its effect on salinity is well documented in the region (Wood, 1924; Lightfoot *et al.*, 1964; Peck *et al.*, 1973). Similarly the more rapid rehabilitation of a deforested area by planting of resistant eucalypts in close stands is not greatly different to rehabilitation of an area mined for bauxite, as it involves mounding and/or ploughing, closely spaced planting and fertilization. This, too, is becoming increasingly better documented (Harley, 1976).

The chief difference between the hydrological impact of the dieback disease, and the more directly man-induced perturbations such as mining and clearing, is that dieback generally acts slowly, and is to some degree selective. However, the basic pattern of reduction in evapotranspiration as vegetation is removed, and increase in evapotranspiration as a vegetation is either rehabilitated artificially or recovers naturally, still holds good. It could in fact be argued that the various perturbations discussed above are merely variants of the same problem which forms a continuum from complete absence of perturbations, through gradual or partial removal of vegetation which characterizes many silvicultural operations and parkland clearing, to sudden and complete removal of all vegetation which characterizes mining, arable agriculture and plantation establishment. Similarly the difference between natural revegetation of cleared, cut-over or disease-affected areas, and their rapid rehabilitation by site preparation, planting and fertilization, is one of a degree rather than of a kind.

THE EFFECT OF PLANTATION ESTABLISHMENT ON WATER QUALITY

The nature and magnitude of the impact varies with environmental conditions. Studies by Batini, Selkirk and Hatch (1976) indicate that on the sandy soils, which appear incapable of storing salt, the increase in through-put of water through soil profile will not be

associated with significant adverse rise in salinity of the streams, except perhaps where heavier soils with stored salt are affected downslope.

Such was the case at Mt. Cooke, where the vegetation of a broad upland valley between Mt. Cooke and Albany Highway was strongly affected by dieback. The residual vegetation was bulldozed, the area was ploughed and planted with pines. A portion of the area was given additional experimental treatments such as mounding and fertilization. On the valley floor, only plants planted on the mounds survived, but further up the slope planting was quite successful. At the time of planting, underground water was welling-up under pressure on the valley floor as mud volcanoes. Some pines on the mounds subsequently died, and testing of the groundwater and of adjacent minor stream revealed quite high salinity levels. As the surrounding plantations grew up, the mud volcanoes disappeared, and the valley as a whole dried up. It is possible that predominantly dry years since 1969 have helped, but the change has certainly been most marked.

Similar drying up of upwelling saline ground water occurred in Well-bucket Plantation, which occupies a repurchased grazing property in Upper Helena River. However, the salinity levels of the streams originating in the area still remain high, possibly because portions of the uplands still remain under annual pasture. Relatively high salinities have been observed by Batini and Selkirk (pers. comm.) in streams originating in other pine plantations in the Helena catchment, only some of which occupy former pasture land. It would therefore seem that pine plantations reverse the trend toward higher run-off quite rapidly, but their effect on salinity appears to be more drawn-out. A purely speculative interpretation could be that the root system of pines requires time to fully reoccupy the soil, and in the meantime saline groundwater leaches into the streams. The root system is, in any case, markedly more superficial than that of jarrah, particularly on heavy textured soils.

The two cases so far described refer to plantations in the medium to low rainfall zone (below 1000 mm). Plantations in high rainfall zone (over 1000 mm), such as in the catchments of Brunswick and Harvey Rivers, do not appear to increase salinity to any extent. It is here, however, that problems with increase in turbidity could have been expected, as the high rainfall plantations generally occur on steep slopes with loamy soil.

THE EFFECT OF DIEBACK DISEASE ON WATER QUALITY

An examination of the Public Works Department's 1973 stream data in the light of known catchment characteristics suggests that some of the catchments most affected by dieback (Waterfall Gully, Seldom Seen, Bancell) have high yields which cannot be explained solely in terms of topography, soil and climate. Comparison with similar but dieback-free catchments (Davies) suggests that dieback ultimately results in marked increases in yield. In the western catchment, this occurs without any marked increase in salinity. The increases appear to be

very marked, raising the yield from 12 to 20 or even 30 per cent of incoming rainfall (Havel, unpublished data).

The limitation of the above speculations is that Public Works Department data normally refer to catchments of considerable size, and hence comprising wide variation in climatic and edaphic factors. More recent studies by Shea and Hatch (1976) and Shea and Herbert (pers. comm.), which provide short term records of yield and salinity of micro catchments in the Yarragil and South Dandalup catchments, suggest that my speculations, far from being extravagent, are in fact conservative. It appears that tenfold differences between micro catchments in yield and salinity are not unusual, and that the high degree of dieback infection in the western catchments is responsible, at least in part, for their very high yields as compared with the more easterly catchments, in which dieback is either absent, or much more recent and less extensive.

Destruction of vegetation by dieback in some medium rainfall sub-catchments north-east of South Dandalup Dam appears to have also led to an increase in stream salinity. This was also the case in the Mt. Cooke area, mentioned earlier. Fortunately dieback occurrence is so far markedly lower in the eastern, salt-prone zone than in the western relatively salt-free zone.

THE IMPLICATION OF HYDROLOGICAL FINDINGS TO FOREST MANAGEMENT

What implication does this have on forest management? It would appear that dieback is not universally a disaster, at least not from the hydrological viewpoint. In the western high rainfall zone the best treatment of dieback affected sites is probably to do nothing, as the increased yield of water is not negated by increases in salinity or turbidity. To re-establish a dense forest cover would almost certainly result in return to lower yields. It may, in fact, be even desirable to limit the density of natural revegetation by marri, yarri and bullich to relatively open stands. Far more difficult to control will be the spread of phreatic vegetation, in particular tall dense scrub of *Agonis linearifolia*, resulting from higher ground watertable, as its transpiration rates are no doubt very high.

By contrast, the main motive for the re-establishment of dense cover on dieback-affected catchments in the eastern low rainfall zone should be the prevention of rise in salinity of streams, rather than the restoration of relatively meagre timber-producing capacity. The converse of this is that the spread of dieback disease in the eastern catchments would be highly undesirable from hydrological as well as forestry viewpoint (Shea *et al.*, 1975; Havel, 1975).

As for plantations, their future in the northern jarrah region is rather bleak. Clearing, cultivation and the use of weedicides close to reservoirs are rather risky, so that pine planting has been abandoned in the western valleys despite high rainfall and relatively high fertility. On the adjacent uplands, pine planting is handicapped by the strong phosphate-fixing capacity of the lateritic gravels. On the fertile loams of the Blackwood, pine planting can go on without significantly affecting the already high salinity of the Blackwood River.

In the Sunkland, the mediocre soils can be improved by fertilization, and the resulting plantations adjusted by thinning to produce water yields comparable in quantity and quality to native forest, which in any case is already strongly affected by dieback. In the eastern low rainfall catchments, tree planting on agricultural land is highly desirable. However, the salinity risk involved in clearing native forest to establish pine plantation is too great in this zone, and is not justified in light of lower productivity.

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CONTENTS