The Effect of Changing Hydrological Processes on Remnant Vegetation and Wetlands

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INTRODUCTION

Remnant vegetation and wetlands on both private and public land are rapidly being degraded by dryland salinity, inundation, silting, nutrient enrichment and weed invasion. Remnants in the lower parts of catchments are most affected. Many cannot be saved without expensive and integrated programs to reduce the degradation of agricultural catchments in which they are located. There is an urgent need to identify those remnants which have the highest values and for which cost-effective recovery plans can be developed. In most cases, it is not possible to manage these remnants in isolation from the surrounding catchment, and society will need to contribute to the cost of catchment management if the nature conservation values of these remnants are to be retained. Innovative methods need to be developed which maintain the nature conservation value of the remnants at the same time as increasing the soil conservation and farm production benefits that they provide for farmers. It is only when the on-farm remnants are seen as being important for land-holders that they will be properly managed.

This review concentrates on the hydrologic benefits afforded by remnants and the threat posed by hydrological forms of degradation. We have opted to use the case study approach to highlight the major issues affecting remnants in the Wheatbelt. Our case studies are mainly from our current and past research activities. A more detailed account of our research is presented elsewhere (George *et al.* in press).

HYDROLOGICAL PROCESSES IN REMNANT VEGETATION

Surface Hydrology

Mallees have been shown to harvest water with their vase-like branches, directing stem flow to their bases, where it infiltrates deeply beside roots (Nulsen *et al.* 1986). This practice reduces soil evaporation and provides the plants with water during the dry summer and autumn period. Salmon gums (*Eucalyptus salmonophloia*) and gimlets (*E. salubris*) also appear to harvest water, although no measurements have been made.

Water harvesting also appears to be occurring differentially in open areas between trees in the Wheatbelt. Nulsen *et al.* (1986) recorded up to 7.7 mm of overland flow coming from 4 m^2 plots in a bush catchment during a 30.9 mm storm. However, there was almost no runoff recorded from the catchment further downstream. Local redistribution of water among the vegetation accounted for the lack of stream flow. In contrast, organic crusts were suspected of causing low infiltration and sorptivity in four Wheatbelt soils within bushland in comparison with adjacent soils within cleared catchments (McFarlane *et al.* 1992a). Gravelly soils were also more water repellent before clearing. Soils in undisturbed remnants have low levels of the radioactive fallout product caesium-137, further indicating that there is considerable local redistribution of water in Wheatbelt remnants (McFarlane *et al.* 1992b). Infiltration must be concentrated at selected points, as little runoff is observed leaving remnant vegetation.

The fate of macropores formed by tree roots after clearing is poorly known. However, anecdotal evidence suggests that they become clogged or sealed, resulting in increased waterlogging of surface soils. Some remain open, as evidenced by the rapid responses by some watertables to rainfall (Engel *et al.* 1989; George *et al.* 1991).

Native C4 grasses have different water use patterns from introduced (predominantly annual) C3 plants. Prior to agricultural development, soils were wetter in spring and drier in autumn (Johnston 1993). Advantages of the native grasses include deeper rooting, greater water use, lower nutrient requirements and better distribution of feed throughout the year.

Groundwater Hydrology

There are numerous examples of groundwater levels rising after clearing of native vegetation in the Wheatbelt. Generally, water levels are rising by between 0.2 and 0.5 m per year in the above 500 mm rainfall zone, and by between 0.05 and 0.2 m per year in the below 500 mm rainfall zone (George 1992). In some higher rainfall areas, watertables have risen over 25 m since land clearing which occurred less than 80 years ago.

Recharge occurs throughout most of the landscape (George *et al.* 1991). Processes may differ depending on the soil type, and include:

- matrix recharge in soils with low water-holding capacities (for example, deep sands and gravels);
- matrix recharge in arkosic sands below granite outcrops;
- preferred pathway recharge in duplex soils on hillsides, and below sandplain seep discharges;
- preferred pathway and matrix recharge in inundated valleys after storms.

The proportion and total contribution of each form of recharge depend on the distribution of soils and landforms in each catchment. No study has accurately determined the relative contributions. From a management viewpoint, it makes most sense to reduce the recharge in that component which is most cost-effective or which offers other benefits (for example, drying out sandplain seeps, revegetating low-productivity rock outcrops, and draining duplex soils prone to waterlogging).

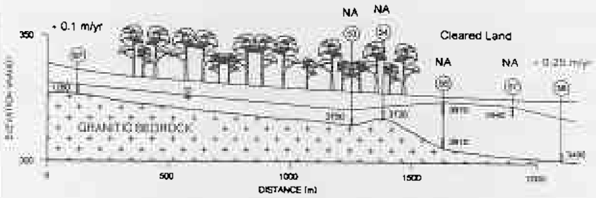
EFFECTS OF REMNANT VEGETATION ON LAND DEGRADATION

Salinity

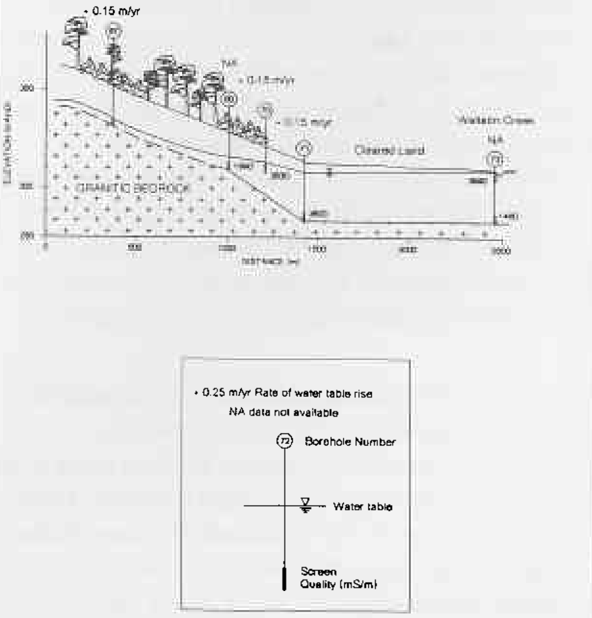
Transects of boreholes were drilled into Durokoppin and Kodj Kodjin Nature Reserves, to study the impact of native vegetation on dryland salinity in the adjoining catchments (McFarlane *et al.* 1992c). The watertables in both reserves are up to 7 m lower than in equivalent landscape positions in the adjoining cleared areas (Figure 1). Salinity affected only 0.1% of the farmland in the agricultural catchment that contains the reserves. In contrast, over 2.8% of the farmland in an extensively cleared adjoining catchment was salt-affected. Recent monitoring within the reserves indicates that watertables are rising at about 0.15 m per year, suggesting that groundwater is moving into the reserves from surrounding land. High groundwater levels under cleared areas next to the Durokoppin Nature Reserve are beginning to affect the south-western and south-eastern parts of the reserve. However, both Durokoppin and Kodj Kodjin Nature Reserves appear to be safe from major salinisation, as the reserves occupy most of their catchments.

Figure 1. Lower groundwater levels under native vegetation in nature reserves from George *et al.* in press.

A. Durokoppin Nature Reserve



B. Kodj Kodjin Nature Reserve



Eutrophication

Dense native vegetation around streamlines is seen as one of the most effective means whereby phosphate attached to suspended sediment can be removed from runoff before it enters estuaries (David Weaver pers. comm.). Weaver (1991) noted that up to 60% of the total phosphate washed into the Kalgan River in 1991 was attached to mobile sediment.

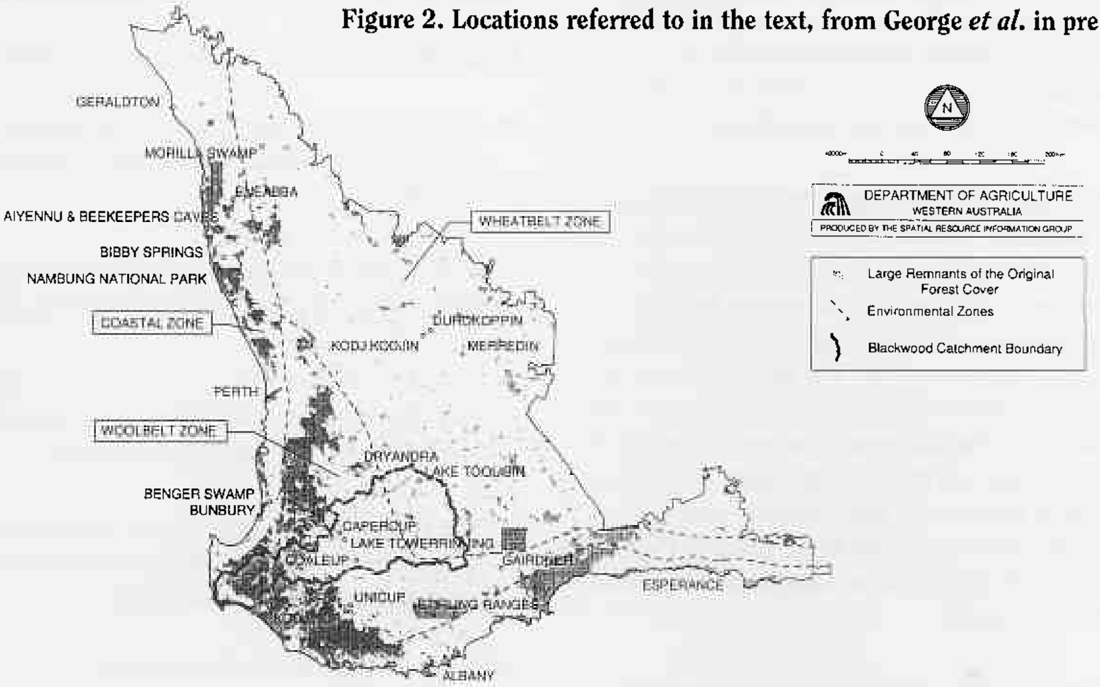


Figure 2. Locations referred to in the text, from George *et al.* in press.

LAND DEGRADATION AND REMNANT VEGETATION

Salinity — Public Land

Olsen and Skitmore (1991) reviewed the effect of salinity, erosion, sedimentation, eutrophication and weed invasion on the state of the rivers in Western Australia. Some of these rivers form corridors of public land through farmland (for example, Kalgan River), whereas others are privately owned. Few rivers are fenced to protect them from stock, although there are projects under way to fence some riverine vegetation — for example, parts of the Denmark, Avon and Kalgan rivers.

The effects of high groundwater levels under cleared areas next to the Durokoppin Nature Reserve are described in the previous section. This case study is an example of the hydrological relationships that may be expected for remnants high in the landscape, at least in the eastern Wheatbelt. Effects lower in the landscape have been, and will continue to be, more dramatic.

Toolibin Lake is located in the middle of a broad valley in a catchment which is 92% cleared of native vegetation. Saline runoff and rising groundwaters threaten the lake and its reserves (Stokes and Sheridan 1985; McFarlane *et al.* 1989). Increased frequency of inundation is thought to be contributing to the death of fringing species (Mattiske 1982). Active intervention is being undertaken, and both a technical advisory group and a recovery team have been appointed to begin the task of protecting the lake and its flora and fauna (Toolibin Lake Recovery Team and Toolibin Lake Technical Advisory Group 1994). Works to by-pass highly saline surface flows around the Lake have been completed in conjunction with catchment and reserve drainage schemes. Groundwater pumping and other actions are planned. It is likely that the only way to preserve the Toolibin environment will be to isolate it from the catchment in order to prevent saline waters from entering it on all but very wet years. Issues raised by work at Toolibin are as follows:

- Toolibin and its reserves will become badly degraded unless protected from saline groundwaters and saline runoff.

- The ecological value of the lakes needs to be clearly enunciated by both the local communities and the managing agency.

- Protection carries large implementation and running costs.

- Restoration of the pre-clearing environment may never be possible. Moreover, the preservation of remnant ecosystems appears impossible in Wheatbelt landscapes. Conservation of selected components may be all that is practical.

There are many other examples of threatened nature reserves. Capercup Nature Reserve is a wandoo (*E. wandoo*) woodland located 5 km west of Duranillin. Recent drilling has shown that the reserve has very saline groundwaters (2 000– 6 000 mS/m) within 2 m of the surface on its western side. The groundwater is as close, but much fresher (300 mS/m), on its eastern side. Most of the adjoining catchment has been cleared in the last 15 to 30 years, and groundwater levels are believed to be rising by between 0.3 and 0.5 m per year. It is likely that the western side will begin dying in the next few years, and about 50% of the reserve will be affected within the next decade.

Kulikup Lake, another nature reserve, is located 15 km east of Boyup Brook. It is covered by reeds and fringed with paperbarks, wandoo and flooded gums. At present, the lake appears to be safe from salinity for about 20 years, as the watertable is over 9 m below the surface and has a moderate salinity (450 mS/m). The Department of Conservation and Land Management (CALM) has monitored the surface water in the lake for over a decade. We believe groundwater monitoring is essential in all nature reserves.

The Qualeup lakes and associated nature reserves are located 25 km west of Kojonup, and range in cover from reed beds and paperback swamps, to wandoo and flooded gum (*E. rudis*) woodlands. In some cases, the lakes already have saline springs emerging within them (Wardles Bush Lake — not a reserve); in others, the watertable is still 4–11 m below the lake's floor (Wardles Grassy Lake, catchment 60% cleared). At Qualeup Lake itself, the watertable is near the surface on the western side and about 4 m below on its eastern side. The waters are saline (500–2 000 mS/m). Qualeup Lake will begin to deteriorate in the next five years.

Groundwaters responsible for salinisation in the Capercup, Kulikup and Qualeup reserves are difficult to manage, as they are often contained in fault zones or small artesian fluvio-lacustrine deposits. The lakes and wetlands contain some species of native, perennial shrubs and grasses that may have agricultural value.

Issues that this section has raised are as follows:

- CALM and associated agencies must begin a program of risk evaluation for the reserves they manage.

- Drilling observation wells in threatened reserves should be a major target for the next five years.

- The reality is that many reserves may die before management plans are implemented. This should be noted from the risk evaluation program.

- Programs to preserve the genetic diversity of threatened reserves should be commenced (for example, seed collection schemes).

Salinity — Remnants on Private Land

Saline groundwaters are rising around the Pallinup River as a result of land clearing. Saline seeps around the river are affecting native vegetation on both private and public land. Natural drainage in the Wellstead area is into yate (*E. occidentalis*) swamps that were perched above the regional groundwater system. Rates of groundwater rise of about 0.3 m per year have been reported from the western south coast over the last 19 years (McFarlane 1992), and many lakes are now becoming salt-affected.

Yate swamps throughout the south coast are under similar threat.

In some places, the yate swamps are the major form of remnant vegetation. Their loss would greatly reduce the habitat for fauna in the region. Unfortunately, it will be difficult to prevent groundwaters from rising in these areas without major changes to farming systems. Crops and pastures are affected by waterlogging, and the main outlets for drainage of this land are the swamps. There have been no definitive studies of the long-term costs and benefits of drainage practices.

Valleys containing wandoo remnants north-west and south-west of the Qualeup lakes are beginning to become saline, and swampy areas have begun to die. Hillside seeps have developed above lakes on many properties, and saline water is collecting in them.

Gibbs Swamp is a small lake on private land about 15 km west of Boyup Brook. The lake is covered by flooded gum and paperbark communities. The local catchment group (Boree Gully) has successfully established local vegetation near the swamp. Drilling has shown that both the deep and shallow aquifers are highly saline (1 200–2 000 mS/m) and that the shallow watertable may already be adversely affecting the swamp. Monitoring has been started, to evaluate whether the revegetation will be successful.

Drilling under wandoo vegetation on the Boyup Brook Golf Course located very saline groundwaters (7 000 mS/m) which are discharging from a clayey regolith. It is sobering to note that the golf course design, essentially based on 'alleys', with 30–40% of the lower catchment under woody perennial vegetation, is inadequate to prevent salinisation and death of the wandoo trees.

On properties near Duranillin, large areas of valley remnants of wandoo and associated species have been fenced from stock. However, rising watertables threaten many of these remnants.

Many lakes and wetlands in the Unicup area are also beginning to degrade as a result of clearing in the 1970s and 1980s. Saline waters flowing from the Unicup lakes and surrounding farmland threaten Kodjinup Lake and its reserve, and the Buranganup Plain wetlands. On some farms, lakes are beginning to fill with groundwater, and overflow, their highly saline waters (2 000–6 000 mS/m) causing pollution. This is also happening in saline lakes within some reserves (for example, Pindicup Lake). Both these lakes overflow into adjoining reserves.

The points that these investigations have raised are as follows:

- Farmers who have fenced and protected valley remnants may not gain much value from their investment. In particular, wandoo woodlands and yate swamps that occur in valleys are under threat.

- Drainage may be essential to maintain the productivity of farmland and to preserve the lakes and wetlands.

- In the Unicup area, lakes on both farmland and reserves are filling, and saline water is beginning to affect other reserves downstream. Active drainage systems are required urgently.

RECOMMENDED ACTIONS

- The beneficial and detrimental effects of agricultural drainage on the long-term viability of remnants in representative areas of the South West need to be established. Studies which concentrate on the short-term effects of drainage on the remnant and ignore what is happening in the rest of the catchment are likely to be misleading.

- There is an urgent need to identify those remnants that have the highest values and for which cost-effective recovery plans can be developed. Groundwater monitoring is needed, to identify areas that are at risk and may be helped by early intervention.

- Understanding the water relations of native vegetation may be essential for its management and rehabilitation, particularly if water harvesting is as important as it appears in undisturbed remnants. Understanding how native plants manage water may also enable agricultural systems to be developed which result in less degradation. For example, understanding how moort (*E. platypus*) grows so well in sodic grey clays may help the management of these problem soils.

- Forest and woodland ecologists should become much more involved in the development of productive agricultural systems that will reduce the negative impacts of the current systems on remnants.

CONCLUSIONS

Developing economic products from our remnant stands of native vegetation must become a prime role for the new generation of researchers. There is little or no practical use in studying plants and animals that are threatened if a similar amount of time is not put into developing solutions to eradicate the factors leading to their demise. If we fail in this task, within our lifetime we will probably lose over 80% of remnant ecosystems on private land and as much as 50% within public reserves.

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TEN YEARS ON

A DECADE OF RESEARCH
AND MANAGEMENT

PROCEEDINGS OF THE
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