The causes of saltland — a case study at Esperance

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A series of bores on the Esperance Downs Research Station has demonstrated that groundwater levels change after clearing, and the relationship between groundwater levels and soil salinity has been emphasised. This pattern of hydrologic change leading to soil salinity problems applies widely in the wheatbelt.

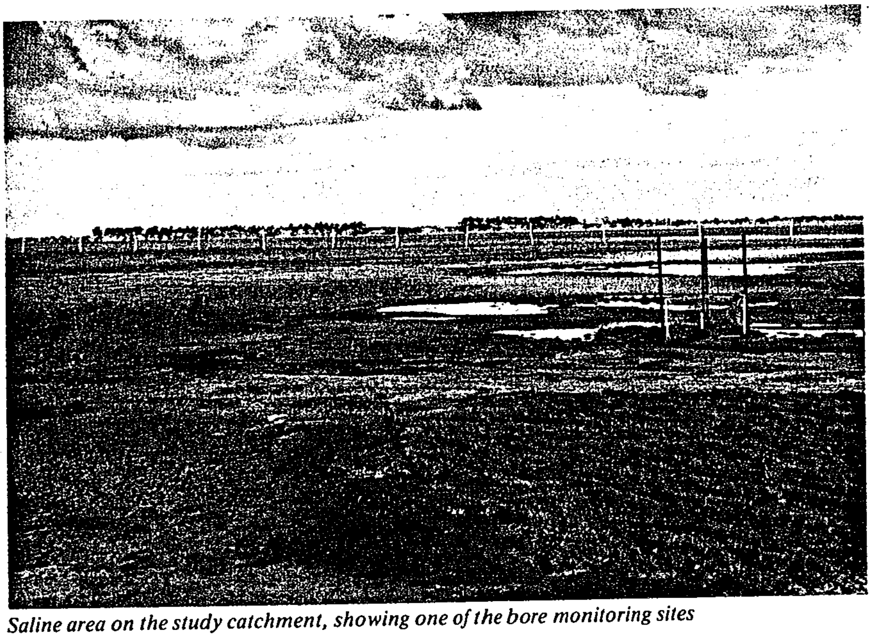
About 170,000 ha of Western Australian farmland have been affected by salt since clearing for agriculture. This is about 1.3 per cent of the total area cleared. In the Esperance Shire in 1974 only 0.4 per cent of agricultural land had become salt affected since clearing but the incidence is increasing. As no detailed studies of the causes of saltland had been done in the Esperance sandplain region, a suitable site on the Esperance Downs Research Station was selected for study. The area of salt-affected land on the station has developed since clearing in 1953.

The study area

The Esperance Downs Research Station is 35 km north of Esperance on the southern edge of a slightly undulating plateau about 150 metres above sea level. The station lies in the upper reaches of the Dalyup River where drainage lines are chains of salt lakes or broad flat saline channels which flow very sluggishly during winter and are dry during the summer.

Figure 1 shows the location of the salt-affected areas on the research station and the 358 hectare study catchment. East of the main road through the catchment is 190 ha of cleared farm land and on the west side is 168 ha of natural vegetation. The figure also shows some of the nearby naturally saline drainage channels.

The study catchment is relatively flat and surface drainage to the west is poor, with flooding in wet years. The saline soils are often focal points for wind erosion because the fine, sandy-surfaced soils are particularly vulnerable when bare.



Saline area on the study catchment, showing one of the bore monitoring sites

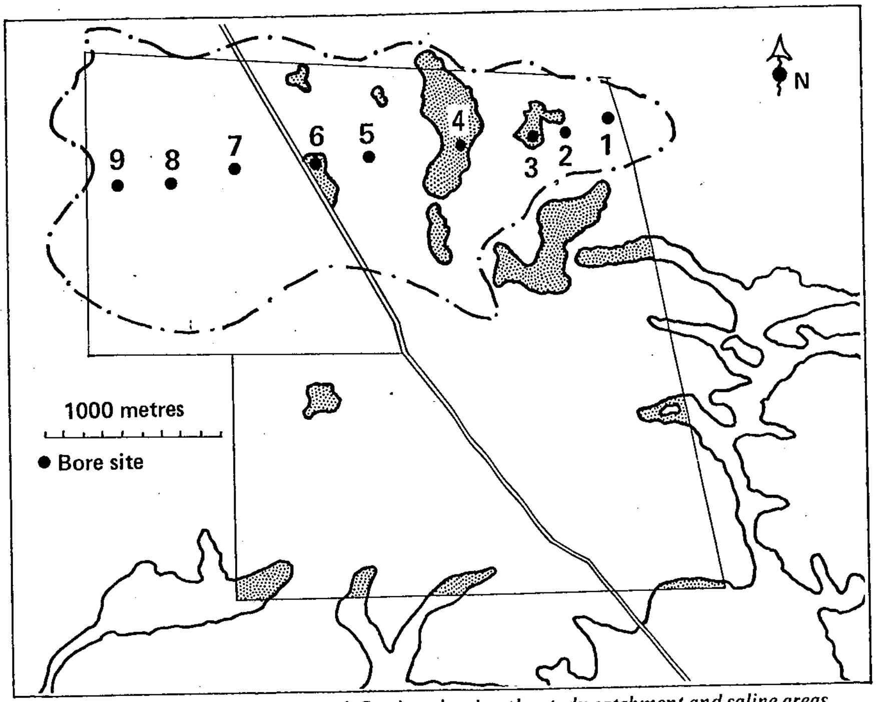


Fig. 1. — Esperance Downs Research Station showing the study catchment and saline areas. Bores 1 to 6 are in the farmed areas and bores 7 to 9 are in the uncleared areas. The saline drainage channel and the small creek issuing from the study catchment join the Dalyup River

Groundwater monitoring

A network of monitoring bores was established over the catchment to assess the depth and salinity of groundwater and the depth to bedrock. Figure 2 is a cross-section through bores 1 to 9, shown on Figure 1. The bores are designed to show true water table levels. Figure 2 illustrates the following points in relation to groundwater levels and salinity development:

- The water table shows a 'mound' of groundwater under the cleared areas.

- While the water table is relatively flat and close to the ground surface in the cleared area, under the uncleared area the water table is steeper and generally deeper. This pattern exists throughout the year.
- Salt-affected areas are shown and it is evident that where the water table is closest to the surface, salinity problems have developed. For contrast, the likely pre-clearing water table level is also shown. The indicated rise in groundwater levels of up to 10 metres is not unusual and has been recorded in a number of areas; for example, old bore records for the Lake Toolibin area near Narrogin show that water tables have risen up to 11 metres above pre-clearing levels, and CSIRO work at Bakers Hill has recorded a steady rise in water tables of about 0.4 metres a year since clearing.
- The uneven basement rock is evident and where the rock is particularly shallow, groundwater levels are significantly affected. Shallow rock has forced the water table close to the surface around bore 3. This has caused an extensive, severe salt patch on a relatively elevated and sloping site where salinity problems would not normally be expected. In winter, the water table beneath this area is at the surface and because of continued evaporation from the higher water table the area is more severely salt-affected than the lower-lying areas around bores 4 and 6.

Figure 3, which is a contour plan of the catchment's water table surface, indicates that a general groundwater mound is present under the cleared areas. The few widely-spaced contours under the cleared areas contrast with the numerous closely-spaced contours under the uncleared areas.

Water tables and soil salinity

Differences in water table levels and salinities are related to severity of surface soil salinity. A bore in a salt area (bore 3) is compared to a bore in a nearby non-saline area (bore 1) in Fig. 4.

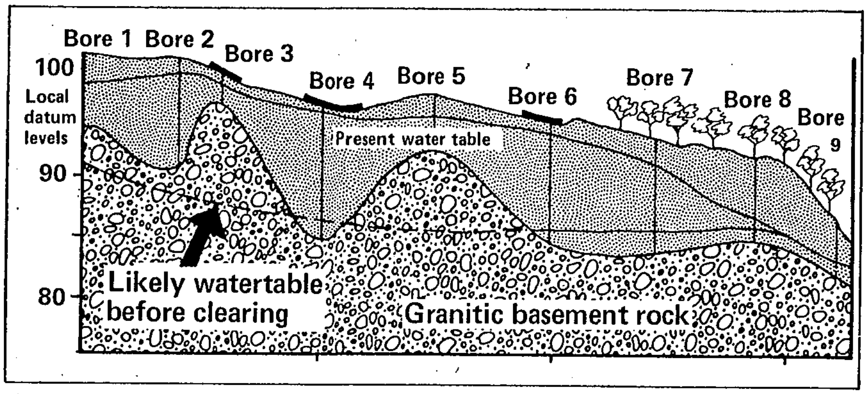


Fig. 2. — Cross section of the study catchment with the present water table near its maximum height in August. Also shown is the likely position of the water table before clearing. Note the uneven surface of the basement rock

In the saline area, the water table, despite annual fluctuations, is generally within 1 metre of the soil surface and during winter is at the surface. From these shallow depths, groundwater can easily rise by capillary action and soil salinity has resulted. Evaporation has concentrated the groundwater to near the salinity of seawater.

Beneath the non-saline area, groundwater levels are on average 2 to 2.5 m below the surface and fluctuate much more than in the salty area. On these sandy-surfaced soils, groundwater at this depth has not caused soil salinity.

Groundwater around bore 1 contains 2,000 to 9,000 milligrams per litre total dissolved solids (TDS) and could be drunk by sheep and beef cattle. In sharp contrast is the groundwater beneath the nearby salt-affected area which contains up to 30,000 mg/l TDS.

The concentration of salts beneath saline soils has caused pockets of very salty water to occur amidst relatively fresh groundwater. This contrasts with the undisturbed bush areas where salt levels increase gradually towards the creekline as expected.

Changing hydrology under agriculture

This study has allowed some of the hydrologic changes caused by clearing to be measured and others to be calculated.

Meteorological records and watertable observations enable a crude water balance to be calculated. Under cleared conditions, about 7 per cent of the annual rainfall percolated down to the water table, while beneath the uncleared areas about 1.5 per cent of rainfall reached the water table. Observations during drilling and limited sampling confirmed that soils were much drier under uncleared than cleared conditions — further underlining the greater ability of the native vegetation to tap the available soil water.

The extent of hydrologic disturbance can also be expressed in terms of the salt balance. Within the study catchment about 20 to 30 times more salt flowed from the cleared area in groundwater than fell in the rainfall. Under the balanced situation assumed before clearing, salt flowing out would roughly balance salt in the rainfall. Sampling has shown 200 to 250 tonnes of salt per hectare is stored in the subsoil and this large store of salt has been mobilised by the changed groundwater conditions. Some of the mobilised salt has been stored elsewhere in the catchment to form saline soils and some is flowing towards the creekline in the groundwater flow.

Flooding

Groundwater contours indicate that during winter, small mounds of groundwater are present under the low-lying water-logged and salty areas due to additional intake from floodwaters. Expansion of salt-affected areas on the situation has been observed to follow periods

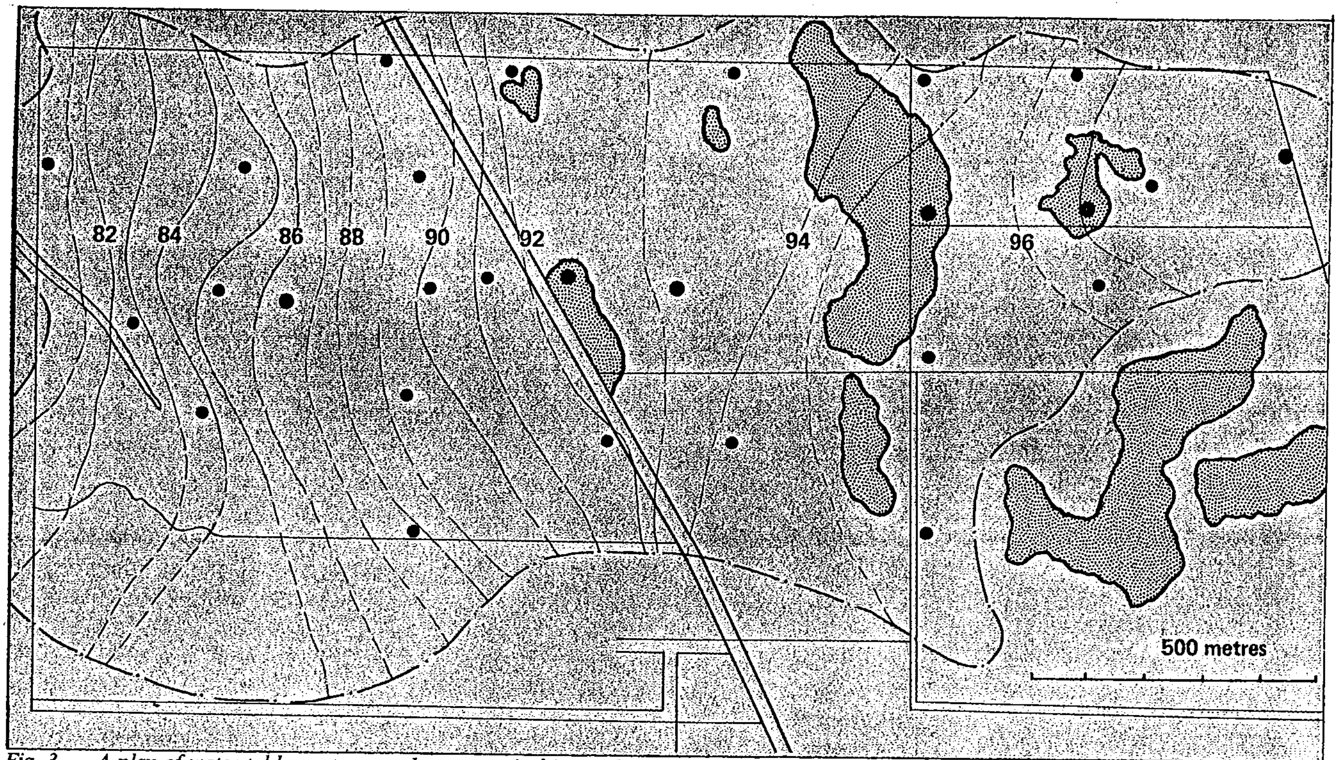


Fig. 3 — A plan of water table contours at 1 metre vetical intervals. The groundwater mound is indicated by the wildely spaced contours under the cleared areas east of the road. This contrasts sharply with the steeper water table under the uncleared areas. Stipled areas are salt affected, and dots indicate bore sites.

of flooding, especially of areas under crop affected by water-logging.

It is apparent that flooding in these areas causes a local rise in the water table and increases the area where the water table is close enough to the surface to cause salinity and water-logging problems. Ensuing poor plant growth causes bare areas which are subject to wind erosion and are more vulnerable to salt accumulation by capillary rise.

Wind erosion, by lowering the soil surface, effectively increases the ease of capillary rise of water from the water table and thus encourages the spread of salt-affected soils.

In this area, surface soils are sandy and the groundwater relatively unconfined so that the effect of flooding on water tables is greater than has been observed in investigations of valley salting in other wheatbelt areas. In these other wheatbelt areas most of the surface soils have been heavier textured and the groundwater more confined.

Reclamation

Reclamation here is defined as removing the salt problem so that the land can be returned to normal production.

One possible agronomic solution is to restore the hydrologic balance by using agricultural plant systems that use as much water as did the natural vegetation. Lucerne, which can be grown successfully in the area, may be able to use this water, being a perennial.

Further study is needed to determine if lucerne can be successfully incorporated into a farm system and effectively increase water consumption over the long term. For drier wheatbelt areas there is currently no prospect of using perennial pastures for increasing water usage by plants.

Information from this study indicates that assuming trees could be strategically placed to intercept seepage to salt areas, about 8 per cent of the cleared area might be needed to be under trees to use the excess water. Further study is needed before confident predictions can be made about the proportion of a catchment which needs to be replanted to trees to alleviate salinity problems. Further study is especially needed to determine where the trees should be positioned on the catchment.

It can be expected that experimental plantings elsewhere in the State, involving research by the Forests Department, Public Works Department and CSIRO, as well as the Department of Agriculture, will lead to a much better understanding of the feasibility of trees for this purpose.

In the saline areas, flooding causes additional groundwater recharge and should therefore be prevented. Shallow drains, by rapidly removing surface water to a safe disposal area would therefore be beneficial. However, surface drains would not lower water tables enough to completely reclaim the salty soils.

To reclaim saltland so that normal crops and pastures can be grown, water tables must be lowered to depths greater than about 2 metres below the soil surface. Apart from water usage by plants, this can be done by either pumping of groundwater or by deep drains. However, drilling has shown no

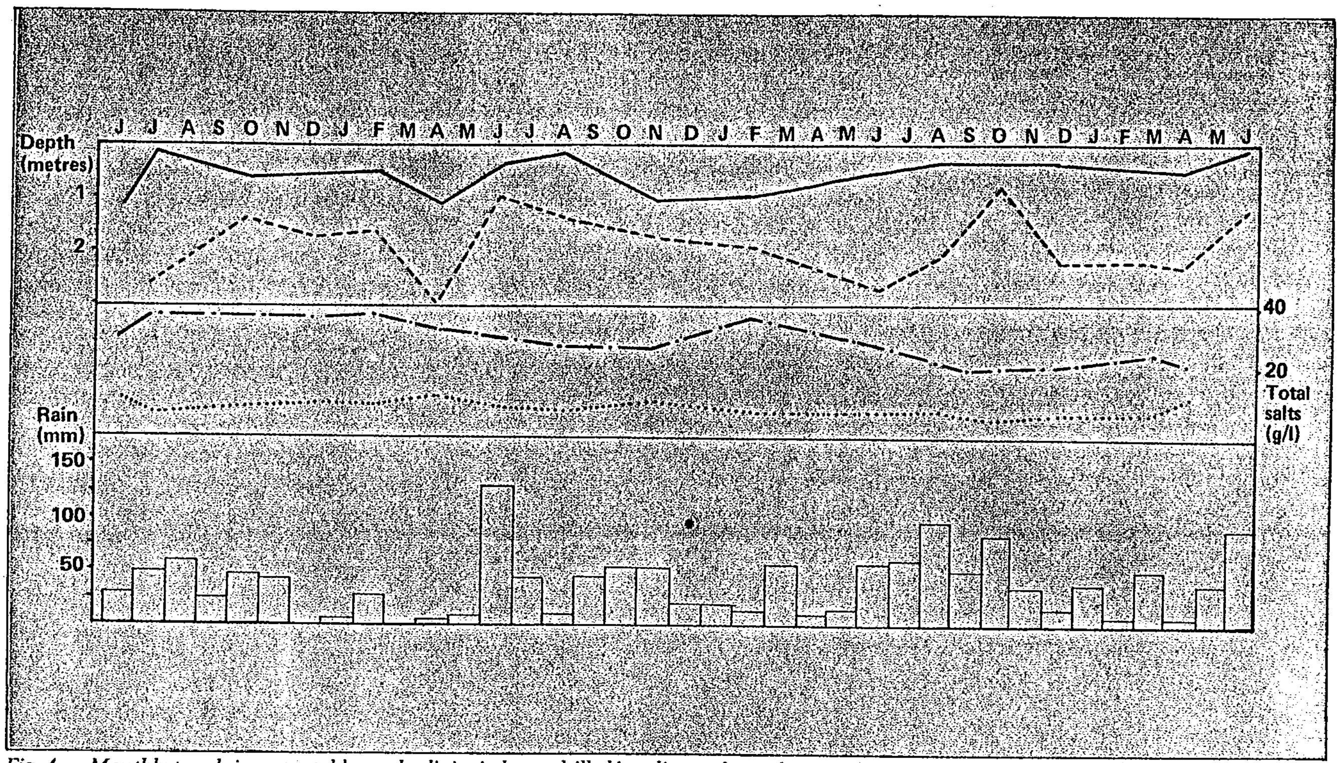


Fig. 4 — Monthly trends in water tables and salinity in bores drilled in saline and near-by non-saline areas. The non-saline bore (bore 1) is shown in the more dotted lines, and the saline bore was bore 3. Monthly rainfall is shown for comparison.

readily permeable aquifer materials such as sand, from which large amounts of water can be pumped. On the other hand, deep drainage may be practicable for specific sites, such as around bore 3, and investigation of this possibility is proceeding.

Acknowledgement

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