Saltland and what to do about it

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Saltland and what to do about it

by C. V. Malcolm, Soil Research and Survey Branch

The area of farm land which is affected by salt amounts to 1.2 per cent of all cleared land in Western Australia. This represents a significant loss to agriculture, as in many cases the land was previously highly productive and on some farms the area affected is hundreds of hectares.

The salt damages the soil by affecting the clay so that it “melts” on wetting, thus losing the structure that allows air and water to enter. This results in poor seed bed conditions, and susceptibility to erosion.

High concentrations of salt in the soil make it more difficult for plants to extract water, and the plants counteract this by absorbing salt. Plants differ in the amount of salt they can tolerate in their tissues, and many agricultural plants, such as wheat and clover, have low tolerance.

The first effect of too much salt is retarded growth, and plants may develop a deep blue-green colour. More severe effects are leaf scorching, withering, and finally death of the plants.

Fortunately, several plant species can maintain normal growth with high concentrations of salt in their tissues. These plants include saltbush, bluebush, samphire, puccinellia and some trees.

Hydrological and detailed soil studies have clarified the nature and cause of salting. Different types of salt problem have been recognised and different management techniques are required for each type.

Research is continuing. Overseas and local plant collection trips have provided over 800 salt tolerant forage species for testing, and the best selections are near release for wide scale planting.

This article describes the best approach to the reclamation of saltland, based on work and experience of the Department of Agriculture.

How saltland occurs

Salts in the soil are similar in composition to seawater, being about 75 per cent common salt (sodium chloride). The salt in the soils of the south-west is believed to have come mainly from rainfall and accumulated over thousands of years. On the west coast 100 to 300 kg of salt per hectare may be deposited each year by rainfall, but only about 15 kg per hectare are deposited 250 kilometres inland.

In high rainfall areas, runoff and drainage remove much of the salt, returning it to the ocean. Further inland, drainage is incomplete and salt therefore accumulates in soils and groundwaters. Over thousands of years this salt has built up to high levels, particularly in the salt lake systems.

Salting problems caused by groundwater occur because the native perennial vegetation has been replaced by annual crops and pasture. These crops and pastures use less water than the native vegetation, changing the water balance of the soil, and promoting a general rise in groundwater levels.

Where groundwater comes close to the surface, evaporation removes water, leaving an increased concentration of salt. As salt increases in the soil plant growth declines,
SALT LAND TYPES

Saltland can be conveniently divided into three main types on the basis of cause. Within each type there is great variation, and the types may merge or overlap. For example, "morrel" soils may be affected by a watertable, and seepage may contribute to the development of valley waterlogging. Treatment can be decided on the basis of the type of saltland. Arrows in the diagrams represent the movement of salt in dust, rainfall or groundwater.

Top. Seepage saltland. Saltland caused by seepage occurs throughout the agricultural areas. It may occur on hill-sides or along gullies and stream banks, and may also occur on the fringes of the broad wheatbelt valleys. Frequently seepage water weeps from the ground surface, causing extreme encrustations of salt.

Centre. Watertable saltland. This is caused by the saline water at shallow depth. The characters vary with the soil types in the valley soils. In some cases (2a) the groundwater is confined and rises into the topsoil under pressure through clayey subsoil layers. In others, it is present unconfined in permeable soil (2b). Where the watertable reaches the surface, salt lakes occur.

Bottom. Dryland salt. Dryland salt occurs in some fine-textured soils with naturally saline subsoils in the wheatbelt, in the absence of seepage or a watertable. These soils characteristically carry morrel or Kondinin blackbutt vegetation.
Right. A soil profile typical of many saline areas. The hard orange subsoil is traversed by soft seams of wet grey soil through which water and salt is leaking toward the soil surface from the semi-confined aquifer.

Below. Two pits dug in a saline flat at Quairading on the bank of a creek bed. Groundwater is leaking under pressure through old root channels into the pit at the rear, and overflowing into the creek. The pit in the foreground did not intersect any major root channels and remains unfilled; lateral flow from the adjacent hole has been insufficient to fill the hole.

and eventually plants die. The resulting bare areas are prone to erosion by wind and water.

- **Watertable or valley waterlogging salt** is the most extensive form of saltland, occurring in depressions and flat valleys with an underlying saline watertable, usually under pressure but sometimes unconfined. This water is often extremely salty (20,000 mg/litre) and its movement to the surface is restricted by the fine texture of the soils of the valley floor. Some properties have over 200 ha of land affected by valley waterlogging salt.

- **Seepage salt** is most common on hillsides and along water courses in the western wheatbelt and mixed farming areas. Affected areas also occur along the junctions of hill slopes and valley floors.

Seepage areas may be caused by water movement at one or more depths in the soil. Commonly, shallow water dries out in the spring, and the seepage areas are then kept moist throughout summer by water coming up from deeper
layers of soil. During spring and summer, salt accumulates in these areas due to evaporation.

Areas of seepage vary from a few square metres to several hectares, and while their total area may be small, they are focal points for water erosion.

- **Dryland salt** is not the result of salty water tables or seepage. Bare patches occur on certain soils due to the movement to the surface of salt which is naturally present in the subsoil. Practices such as over-grazing and fallow encourage the development of these bare patches. The powdery morrel soils of the eastern margins of salt lakes are a typical example.

The mechanisms of salt accumulation are discussed in the next section.

In most salt patches there is a range in conditions from the mildly affected fringes, which may possibly return to normal production, to severe areas which will only grow highly salt tolerant plants.

The best field guide to the salt levels occurring in a particular situation is the plant cover.

- **Mildly affected saltland** has a nearly complete cover of sea barley grass and reduced occurrence of clover, medics and non-salt tolerant grasses. It often gives a reasonable crop, especially if sown to six-row barley.

- **Moderately affected saltland** has a patchy occurrence of bare and grassed areas and only carries a profitable cereal crop if seasonal conditions are especially favourable.

- **Severely affected saltland** is completely bare or only carries highly salt tolerant vegetation such as samphire. Cereal crops will not grow on severely affected saltland.

The differences in severity of salt patches are due to differences in salt and water movement in the soil.

**Movement of salt and water**

The upward movement of water and therefore of dissolved salts to the soil surface occurs in two distinct ways which frequently complement each other.

- **Pressure water.**
  Pressure forces water upwards through the larger soil pores towards the soil surface. The water is under pressure because water enters the soil at a higher level on the slope, but is confined by clay-rich subsoil of the valley floor. The water moves upwards until the pressure head is satisfied.

- **Capillary or suction water.**
  Water is drawn upwards in the fine soil pores. Fine pores in the soil attract water like a wick or blotting paper, with the finest pores having the strongest attraction. This is known as "capillary action".

  The source of water can be either a watertable or wet subsoil, and the upward movement will continue as long as the fine pore capillary action can supply water to the soil surface fast enough to replace that lost by evaporation.

  Coarse sands are least able to keep up the supply of water to the surface because they have few fine pore spaces. Fine textured (heavy) soils are also inefficient at maintaining a wet soil surface because the water supply rate is too slow. Silty loams are the most efficient at supplying water, and therefore salt, to the soil surface.

  Capillary movement of water to the soil surface is strongest and therefore most able to bring salt to the surface, when the groundwater is close to the surface. A rough guide to the relation between groundwater depth and severity of salt accumulation is given below.

<table>
<thead>
<tr>
<th>Severity of salting</th>
<th>Groundwater depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>severe</td>
<td>less than 1</td>
</tr>
<tr>
<td>moderate</td>
<td>1.5-2</td>
</tr>
<tr>
<td>mild</td>
<td>greater than 2</td>
</tr>
</tbody>
</table>

  These depths are approximate and vary with soil type and season.

  Careful examination of the soil is necessary to find the groundwater level, as in many fine-textured subsoils the groundwater is confined and leaks towards the surface through old root channels and cracks in the soil, and not through the soil itself. This movement is due to pressure, and not capillary action.

Small auger holes sunk into the subsoil may not fill with water for a long time if they do not intersect one of these routes of water movement. Large pits are therefore desirable to find the groundwater level.

In some cases, the groundwater pressure brings the water above the ground level. The pressure can then only be measured in pipes sealed into the ground and extending above the ground level. These pipes are called piezometers.

**TREATMENT**

The three aims of a saltland treatment programme are:

- To reduce the groundwater levels or seepage flows as much as possible.
- To reduce the capillary action which brings salt to the soil surface.
- To revegetate the soils with the most useful plants that can survive.

These measures depend on each other. For example, if groundwater levels are reduced, salt accumulation near the soil surface will be reduced, and plants with less salt tolerance may be grown.

**Reducing groundwater levels or seepage flows**

Groundwater levels and seepage flows can be reduced by using more water on the higher slopes. Increased run-off may reduce underground water but is likely to cause erosion and flooding, and is a waste of a valuable resource.

More water can be used by adopting soil conservation techniques such as good plant cover, contour cultivation and, if necessary, contour or grade banks.

However, the effects of soil conservation measures on salting will vary with season and soil type. For example, encouraging water to soak in may increase the groundwater, especially on sandy soils and in wet winters.

Water use may also be increased by growing longer-seasoned, deep-rooting or perennial plants.

It must be remembered that the changes in water use that cause salting occur over large areas, and
major changes in land use may be needed to have an effect on groundwater levels and seepage flows. Such changes may not be justified by benefits to saltland.

Moreover unless appreciable portions of catchments are recovered by perennial vegetation, groundwater levels and seepage flows will be higher than before clearing.

Changes in groundwater levels or seepage due to changes in land use take years to develop. The delay is due to the slow movement of water to the valleys through soil layers, and due to slow leakage of water upwards through soil pores and cracks. As a consequence, the effects of increasing water use will also develop slowly.

Reducing salt accumulation
A bare wet soil surface in spring and summer increases salt accumulation by providing ideal conditions for capillary rise. Salt accumulation at the soil surface can therefore be reduced by drying the surface soil quickly in spring so that upward movement of groundwater is reduced. This applies both to capillary movement from groundwater and from the saline subsoils of dryland salt areas. A surface murch of organic material or coarse sand reduces evaporation from the soil surface.

Overgrazing, fallow, winter waterlogging and flooding tend to leave the soil surface bare and wet in spring or summer. As a result they encourage surface salt accumulation, and should be avoided.

The methods of reducing salt accumulation are listed below.

- Maintain a vigorous plant cover by good crop and pasture management, fertilisation, grazing control and renovation.
- Keep a good plant cover especially in spring and early summer.
- Cultivate to encourage trapping of wind-blowed seeds and encourage rains to soak in to leach salt out of the soil surface.
- Control flooding.
- Reduce waterlogging.
- Do not fallow.
- Do not overgraze.
- Encourage the development of a mulch on the soil.

On mildly affected saltland, the surface is almost completely covered with sea barley grass and groundwater is about 1.5 to 2 metres below the surface. It should be possible to control salt accumulation using a combination of measures to reduce groundwater levels and reduce salt accumulation.

On moderately affected saltland where the surface is bare in patches and where groundwater is about 1 to 1.5 m below the surface, successful reduction of salt accumulation will depend on soil type and season. There will always be the likelihood of poor results from conventional crops and pastures, and special salt tolerant forage plants should therefore be planted.

On severely affected saltland where the surface is almost completely bare and groundwater is about one metre or less below the surface, salt will accumulate irrespective of soil type and management. Such situations are only suited to the growth of highly salt tolerant plants.

Revegetating moderately and severely saline soils
Reducing groundwater levels and salt accumulation should successfully return mild saltland to production, using conventional plants. The same basic approach should be used to improve moderately and severely salt affected land. These measures will increase the chance of success with salt tolerant plants, most of which are not salt tolerant at germination.

In addition, to revegetate saltland, the following principles should be adhered to: protection from grazing; suitable cultivation; improved drainage and planting of appropriate species.

Protection of the area from grazing is the most important single aid to re-establishing plant cover on salt affected soils and it usually requires special fencing. Salt tolerant plants are slow to establish and the seedlings must be protected from grazing in the early stages.

Even if nothing is done after fencing bare areas, most will slowly colonise with natural salt tolerant species.

Cultivation is useful in revegetation for several reasons.

- It allows moisture and root penetration by breaking the surface seal which develops on saltland.

* Note. These depths are approximate and vary with soil type and season.
• The consequent leaching of surface salts reduces topsoil salinity, enabling germination.
• Cultivation leaves a roughened surface which will trap seeds that may have otherwise blown off the windswept bare areas. Tynesd implements are most suitable.
• A roughened surface reduces ground-level wind velocity and thereby reduces wind blasting of young plants.
• Cultivation may be used to kill weeds during the establishment of more useful salt tolerant plants.

Cultivation of saltland should be only as deep as necessary to produce a rough surface.

Cultivation before the rain aids water penetration and salt leaching. Later cultivation is used for weed control as necessary.

Improved drainage may also help revegetate salt affected areas, as poor drainage helps salt encroachment by destroying pasture through waterlogging. Evaporation from the resulting bare, wet ground enhances accumulation of salt.

The surface can be drained by ploughing or grading inwards from two sides to produce a “W” drain connecting flood-prone depressions to the main watercourse.

However, altering the flow in major creek channels by excavation or levee banks can result in legal problems. Persons downstream may sue for damages if water which has been diverted or concentrated damages their land. Deep drainage using “poly” pipe or tile drains to lower the water table is prohibitively expensive.

The choice of salt tolerant plants depends on the severity of salting, rainfall, degree of flooding, and the presence of summer moisture.

On some mildly affected saltland, suitable cultural techniques may enable a return to normal crop rotations. For example, barley has a greater salt tolerance than wheat, making it more appropriate for mildly affected saltland. The barley should be sown after the soil has absorbed a moderate opening rain so that the surface has been leached.

Regular renovation of mild salt areas may be necessary to keep a plant cover over the soil. Annual ryegrass is a useful plant for such cover on mild saltland, although it may become a problem when cropping or where annual ryegrass toxicity occurs. Only certified ryegrass seed should be used to avoid the possibility of introducing annual ryegrass toxicity.

On moderately or severely affected saltland more salt-tolerant plants will be required.

On seepage areas which remain wet with seepage water throughout the summer, seashore paspalum (Paspalum distichum) should be planted. The drier fringes of seepage areas should be sown with puccinellia (Puccinellia ciliata). Puccinellia is also suited to moderately affected saltland in waterlogged valleys.

Severely affected soils in waterlogged valleys are suited primarily to the growth of samphire. Details concerning the growth of seashore paspalum, puccinellia and samphire are contained in publications available from the Department of Agriculture.

For moderately salt affected waterlogged valleys, saltbush varieties are being developed and mechanical harvesting and sowing machinery perfected to enable the growing of salt tolerant forage plants on a large scale.

The best salt tolerant forage plant for dryland salt areas is bluebush (Maireana brevifolia, previously called Kochia brevifolia). Methods of harvesting and sowing bluebush on a large scale are being perfected.

Further reading
“Salt encroachment—the 1974 saltland survey” Bulletin 3999.
“Puccinellia—a grass for saltland” Farmnote 29/76.
“Establishing forage shrubs in salty soil” Farmnote 63/76.
“Paspalum distichum—for salty seepages and lawns” Bulletin 3696.
“Forage production from shrubs on saline land” Bulletin 3945.