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# Dryland salinity – causes and impacts

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## What is dryland salinity?

Salinity is the accumulation of salts (often dominated by sodium chloride) in soil and water to levels that impact on human and natural assets (e.g. plants, animals, aquatic ecosystems, water supplies, agriculture and infrastructure). Dryland salinity occurs in unirrigated landscapes (Figure 1).

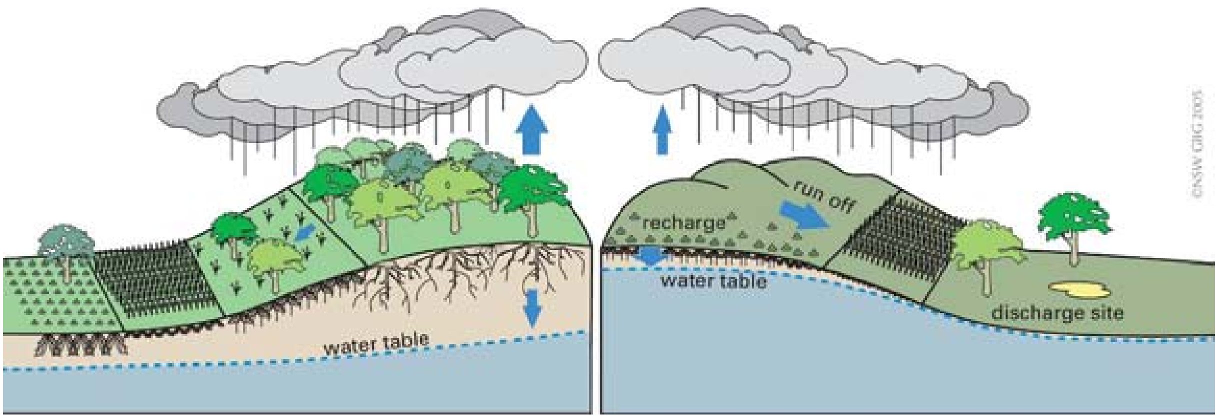
## Primary and secondary salinity

Primary (or inherent) salinity is the natural occurrence of salts in the landscape for example salt marshes, salt lakes, tidal swamps or natural salt scalds. Secondary salinity is salinisation of soil, surface water or groundwater due to human activity such as urbanisation and agriculture (irrigated and dryland).

## Salt sources

Salt may come from several sources including:

- aeolian or wind-borne salt from ocean spray or sedimentary deposits including dune sand and clay particles from the rivers and lakes of the Murray-Darling Basin;
- cyclic salt from ocean spray or pollution dissolved in rainwater then deposited inland;
- connate or fossil salt incorporated in marine sediments at the time of deposition, during periods when Australia was partly covered by sea;
- rock weathering that allows salt to be released as minerals break down over time.




**Trees, deep-rooted perennials and native vegetation use most of the water that enters the soil resulting in reduced leakage past the plant root zone.**

**Removing native vegetation, growing shallow-rooted annuals and long fallowing of paddocks increases leakage to the groundwater system. Watertable rise brings salt to the root zone and the soil surface. Other soil constraints including sodicity may also develop as a result of altered landuse.**

*Figure 1. Causes of dryland salinity. A hydrologically balanced and unbalanced catchment demonstrating vegetation impacts on watertables.* Source: Slinger & Tenison (2007).

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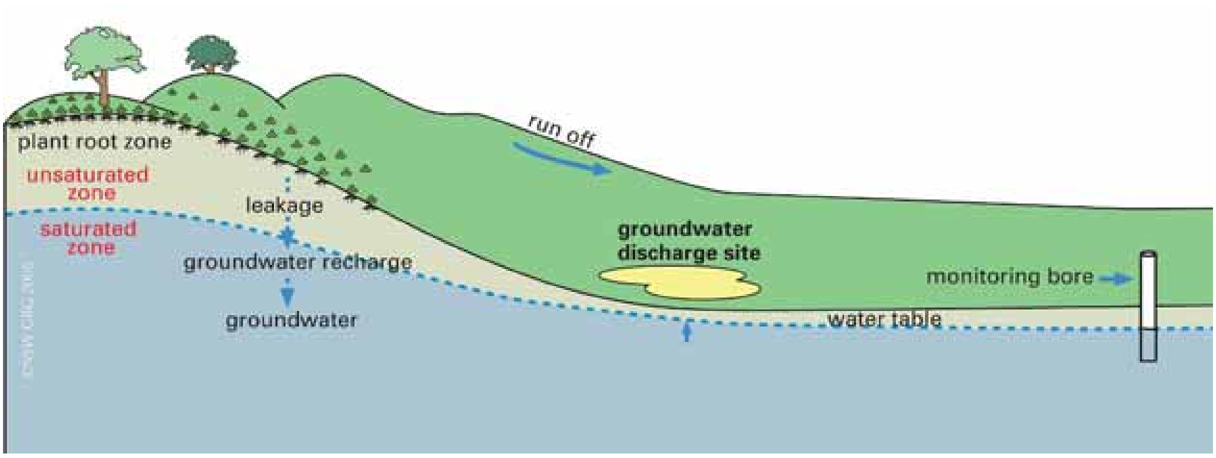


*Figure 2. The groundwater system.* Source: Slinger & Tenison (2007).

## The hydrological cycle

The hydrological cycle is the movement of water from the atmosphere to the earth and back again. Salts are highly soluble, so water is the key to the movement of salts in the landscape.

## The groundwater system

The watertable is the surface below which all the spaces in soil and rock are filled with water. Water in this saturated zone is called groundwater. Above this is the unsaturated zone where the spaces are dry or only partially filled with water (Figure 2).

Water moving downwards past the plant root zone is called leakage. Water may leak from rivers, streams, dams and irrigation channels. Leakage that reaches the saturated zone is called groundwater recharge and groundwater that leaves the saturated zone is called groundwater discharge. Recharge areas are usually up-slope of discharge areas. When groundwater is at or near the soil surface, discharge occurs as seepage, springs, and base flow to streams allowing groundwater to evaporate and/or be evapotranspired.

## Causes of dryland salinity

Dryland salinity occurs where salt in the landscape is mobilised and redistributed closer to the soil surface and/or into waterways by rising groundwater. The watertable rises under dryland agriculture because of increasing rates of leakage and groundwater recharge. This occurs if deep-rooted

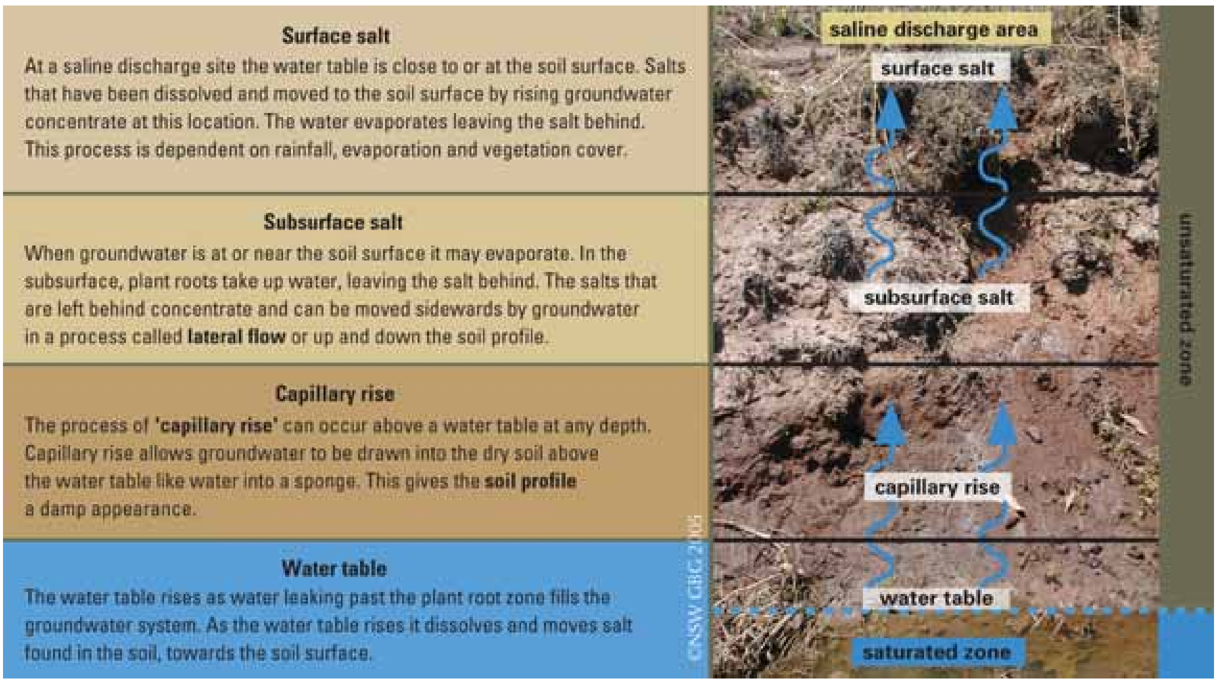


*Figure 3. How salt moves to the soil surface.* Source: Slinger & Tenison (2007).

perennial species such as native trees, shrubs and pasture are replaced with shallow-rooted, annual species and long fallows are incorporated into a cropping rotation.

As the watertable rises, salts found naturally in rocks and soil are dissolved and move toward the soil surface and into the root zone (Figure 3). The salinity risk is greatest when the watertable is within three metres of the soil surface in clay soils (less in sands). Salt that reaches the soil surface will concentrate as the groundwater evaporates.

The salts from saline discharge areas may be redistributed within the catchment, into waterways or into another catchment by water (as surface run-off) and/or wind action.

Rainfall can leach salt down the soil profile and into the groundwater. Dissolved salt can then move laterally with groundwater locally within a catchment or regionally between catchments.

### Leakage factors

The amount of leakage to the groundwater system occurring in a landscape depends on soils, geology, vegetation and climate.

*Soils*

Leakage is potentially less in soils with a higher soil water-holding capacity, as larger volumes of water can be stored and used by plants. Soil water-holding capacity is influenced by soil texture, depth and structure. Coarser-textured soils hold less water and tend to be more permeable and more 'leaky' than fine-textured soils (Figure 4). Conservation farming practices that promote soil health and improve soil structure increase soil water-holding capacity of all soil types.

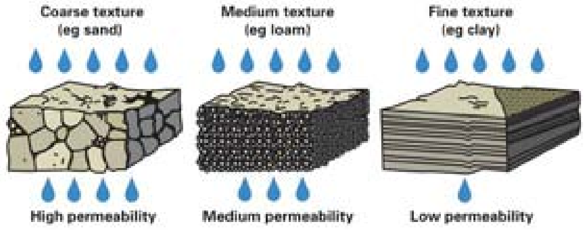


*Figure 4. The permeability of different soil textures influences leakage rates to the groundwater system.* Source: Slinger & Tenison (2007).

*Geology*

Rock type influences groundwater infiltration and movement rates, availability and abundance of stored salts, weathering rates, storage capacity and fracture characteristics. Generally speaking, a solid (or massive) rock unit with little fracturing and low porosity will act as an impervious layer to groundwater. By comparison, unconsolidated sands and gravels will quickly transmit any leakage past the plant root zone.

The main types of geology found in NSW are granite, basalt, metasedimentary and metavolcanic rock, consolidated sedimentary rock and unconsolidated sediments. Unconsolidated sediments generally have the highest leakage rates followed by basalt, consolidated sedimentary rock, granite, metasedimentary and metavolcanic rocks. However, natural variability due to structural

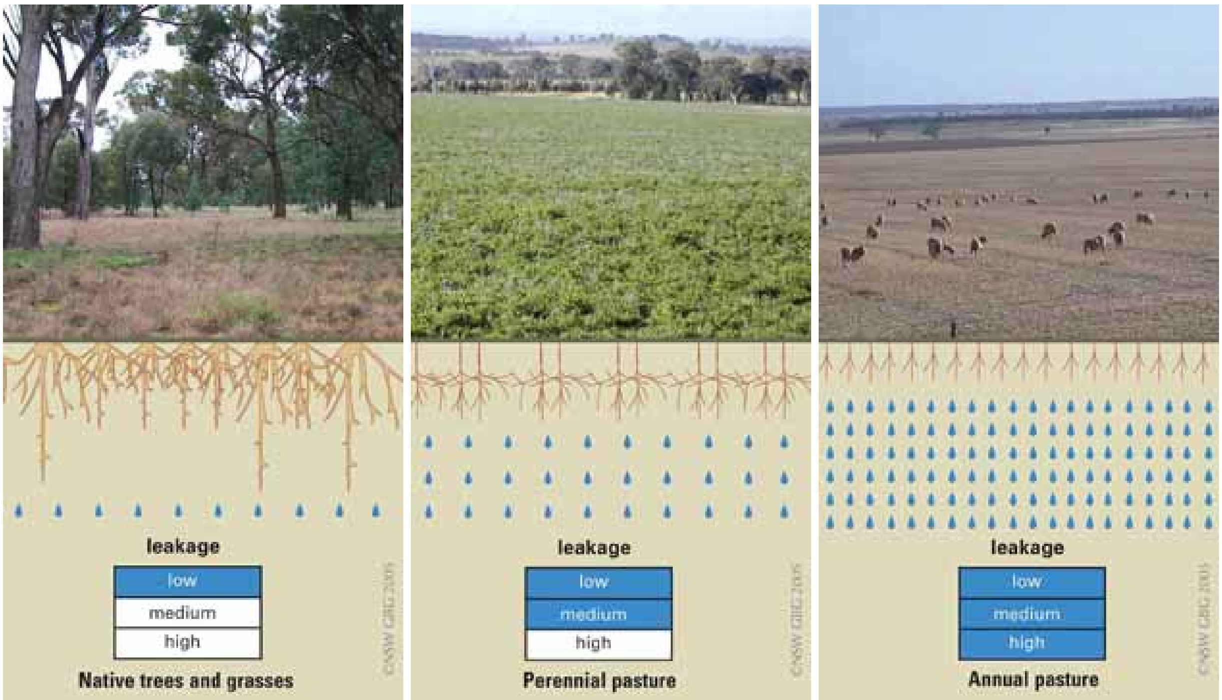


*Figure 5. Leakage comparison between vegetation types on similar landscapes.* Source: Slinger & Tenison (2007).

characteristics, grain size distribution and weathering intensity can result in different leakage rates than would normally be expected.

*Vegetation*

Deep-rooted vegetation such as trees and perennial pasture, for example lucerne, can dry the soil (access and utilise water) to a greater depth than shallow-rooted vegetation (Figure 5). Plant water use is highest when plants are actively growing; therefore prolonging this phase via strategic rotational grazing can reduce leakage.

Summer-active perennial vegetation has the potential to use water over a greater part of the year than annual vegetation. It creates a relatively dry soil profile prior to winter enabling it to store more winter rainfall and act as a buffer to leakage past the plant root zone. Summer-active species such as lucerne should be balanced with winter-active annuals.

*Climate*

The potential for leakage is greater in a ‘wet period’ when average monthly rainfall exceeds evaporation. Figure 6 shows monthly rainfall and potential evaporation averages for selected locations in NSW. Although average annual evapotranspiration rates may exceed precipitation at some locations, rainfall variation (e.g. storms) can contribute significantly to groundwater recharge.

## The effect of salt on plants and soil

### The effect of salt on plants

As salts accumulate in saline discharge areas they can reach levels that affect plants in a number of ways. This leads to poor plant health, a loss of productive species and dominance of salt-tolerant species.

*Osmotic effect*

Under normal conditions, plants readily obtain water from the soil by osmosis (movement of water from a lower salt concentration outside the plant to a higher salt concentration in the plant). As soil salinity increases this balance shifts making it more difficult for plants to extract water from the soil.

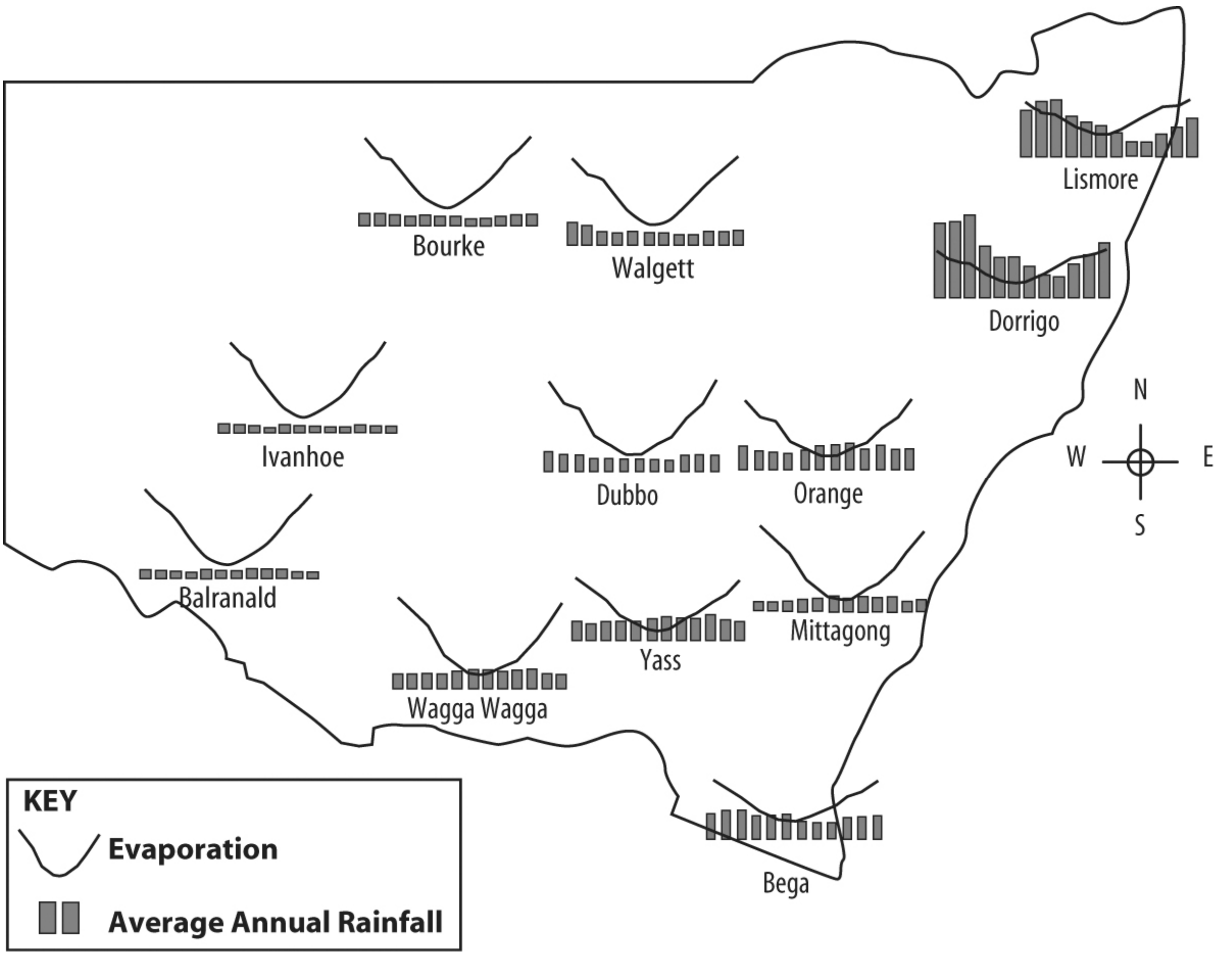


*Figure 6. Monthly rainfall and potential evaporation averages in New South Wales from 1900 to 2006.*
Source: Tenison (2009).


*Figure 7. A hydrologically balanced landscape (left) and unbalanced landscape (right).* Source: Slinger & Tenison (2007).

*Toxic effect*

Plant growth can be directly affected by high levels of toxic ions such as sodium and chloride. Excess sodium accumulation in leaves can cause leaf burn, necrotic (dead) patches and even defoliation. Plants affected by chloride toxicity exhibit similar foliar symptoms, such as leaf bronzing and necrotic spots in some species. Defoliation can occur in some woody species.

*Ionic imbalance*

An excess of some salts can cause an imbalance in the ideal ratio of salts in solution and reduce the ability of plants to take up nutrients. For example, relatively high levels of calcium can inhibit the uptake of iron ('lime induced chlorosis'), and high sodium can exclude potassium.

*Salinity tolerance*

Salt-tolerant plants (halophytes) can tolerate high internal concentrations of salts and take up salt with water. Examples include saltbush (*Atriplex* species) and bluebush (*Maireana* species).

Most agricultural plants fall into the salt-resistant category of glycophytes. They cannot tolerate salt internally but can maintain growth in mildly saline soil by excluding salts at the roots (Greenway and Munns 1980). However, in extremely saline soils glycophytes are unable to both exclude salt and obtain sufficient water for maintenance (DNRQ 1997).The impact of salinity varies with plant species, stage of growth, management practices, varieties and soil fertility.

*Effect of waterlogging on salinity tolerance*

Waterlogging exacerbates the effect of salinity. Waterlogged plant roots are unable to exclude sodium and chloride due to the increased rates of transport of these ions, and concentrations in the plant shoot increase. Poor aeration also affects the soil biology responsible for converting nutrients to their plant available form, causing nutrient deficiencies.

### The effect of salt on soil

Highly saline soils often become highly sodic. The ion imbalance and effect on the soil will depend on the type of salt present. Sodium and magnesium ions can destroy soil structure whereas calcium carbonate may improve soil structure (due to calcium) and increase soil pH (due to carbonate). Highly saline soils may have dark greasy patches where organic matter has been destabilised. On very salty sites a complete loss of groundcover and visible salt crystals often occur on the soil surface making it vulnerable to erosion.

## Impacts of dryland salinity

### Agricultural

Direct costs of increasing salinity to agricultural producers include:

- reduced productivity of agricultural land (Figure 7)
- reduced agricultural production
- reduced farm income
- reduced options for production
- increased input costs to rectify or reduce impacts of salinity
- reduced access and trafficability on waterlogged land
- reduced water quality for stock, domestic and irrigation use
- damage to and reduced life of farm structures such as buildings, roads, fences and underground services and pipes
- animal health problems e.g. saline water supplies
- farm machinery problems (bogging, rusting)

- breakdown of soil structure, increased erosion and nutrient loss
- loss of beneficial native flora and fauna
- decreased land value.

### Environmental

Environmental impacts from land and stream salinity include:

- decline of native vegetation and loss of habitat (Figure 8)
- loss of nesting sites and decline in bird populations
- decline in wildlife fauna other than birds
- reduced food for wildlife populations
- increased soil and wind erosion
- reduced wetland habitat and decline in fish and aquatic populations
- reduced aesthetic value
- reduced recreational and tourism values
- reduced biodiversity in stream fauna, riparian vegetation and wetlands
- increases in weeds and undesirable changes in plant populations
- damage to wildlife sanctuaries and state and national parks.

*Figure 8. Trees die due to inundation resulting from a high watertable and salts.* Source: Slinger & Tenison (2007).

### Social

Impacts on the framework and structure of our society from increasing salinity include:

- reduced aesthetic value of the landscape
- reduced recreational and tourism values
- reduced agricultural incomes due to productivity losses
- flow-on impact on employment
- reduced regional population (in both rural and urban communities)
- increased pressure for consolidation of agricultural properties
- reduced service levels to regional towns (especially <5000 persons)
- increased social adjustment costs e.g. welfare, marriage breakdown and bankruptcy.

## Further reading

Primefact 937, *Irrigation salinity – causes and impacts*

Primefact 938, *Urban salinity – causes and impacts*

Primefact 939, *Salinity symptoms*

## References

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