AUSTRALIAN EARTH SCIENCE EDUCATION

Soil Salinity:
Causes and Rehabilitation

Resourced by

EARTH SCIENCE WESTERN AUSTRALIA

GOLD INDUSTRY GROUP

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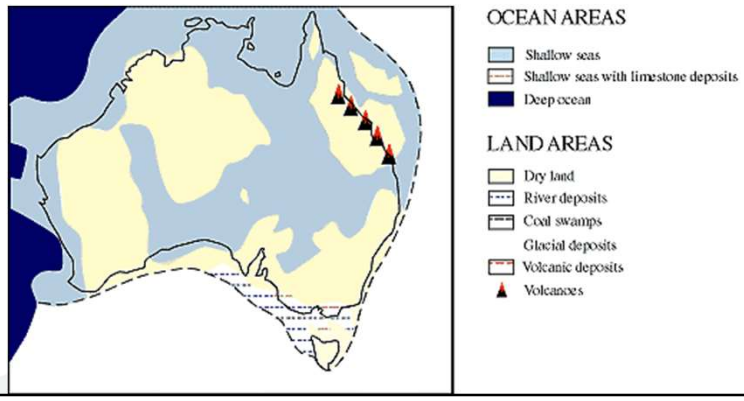
Where does the salt come from?

- Fossil (connate) salt was deposited when sedimentary rocks formed in ancient seas



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The Eromanga Sea covered Australia 110 million years ago during the Cretaceous period. Fossils of plesiosaurs, pliosaurs, ammonites and other sea creatures are found throughout the continent, including the beautiful opal fossils of Lightning Ridge.

Where does the salt come from?

- Aeolian salt is blown inland from sea spray or salt-bearing sedimentary rock deposits

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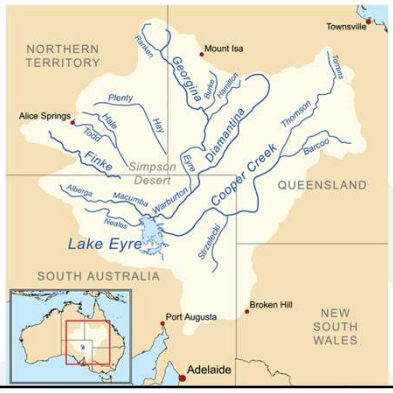
Salt spray has been shown to corrode metal 80 km inland in the UK. (https://pomametals.com/salt-air-inland-distance-for-metal/)
Sea spray travels up to 200 km under normal conditions and further with storm winds from cyclones and east coast lows.

Where does the salt come from?

- Weathering of rocks releases salts
- Australia's topography concentrates salt inland



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Salt is produced by chemical weathering of minerals in rocks. On most continents, salt is carried to the oceans by rivers. However, Australia is unusually flat with a major inland drainage system leading to a low centre (Kati Thanda-Lake Eyre). This keeps salt on the continent where it may be spread by wind when the drainage basin is dry (a frequent occurrence).

Types of salinity

- Dryland salinity
- Irrigation Salinity
- Urban salinity

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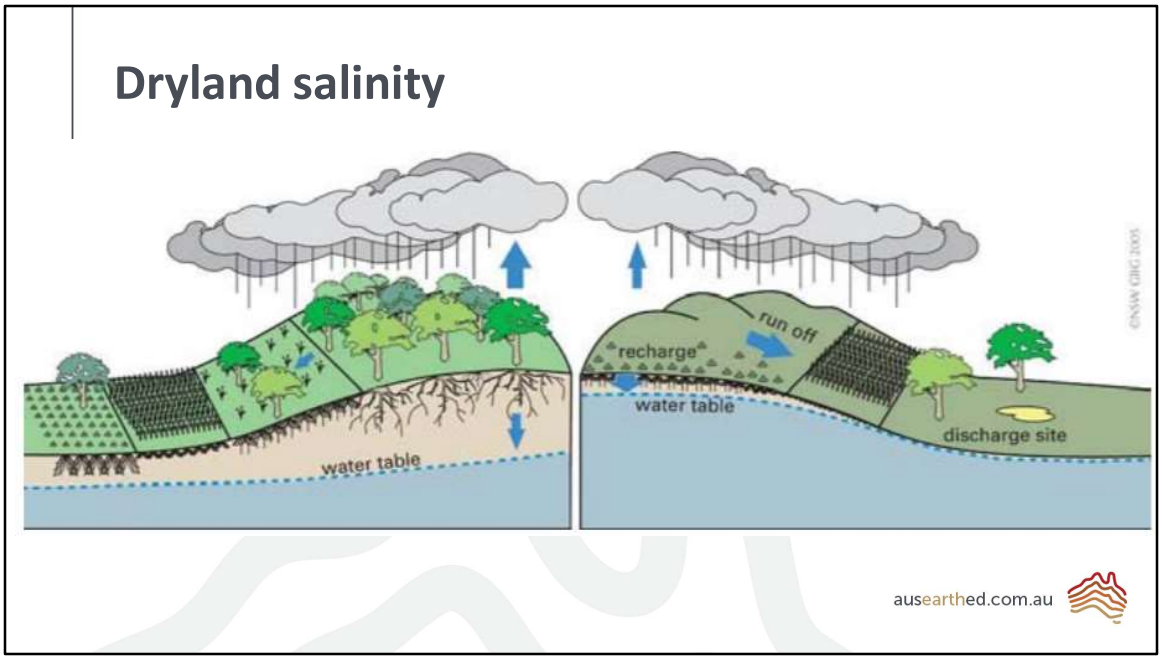
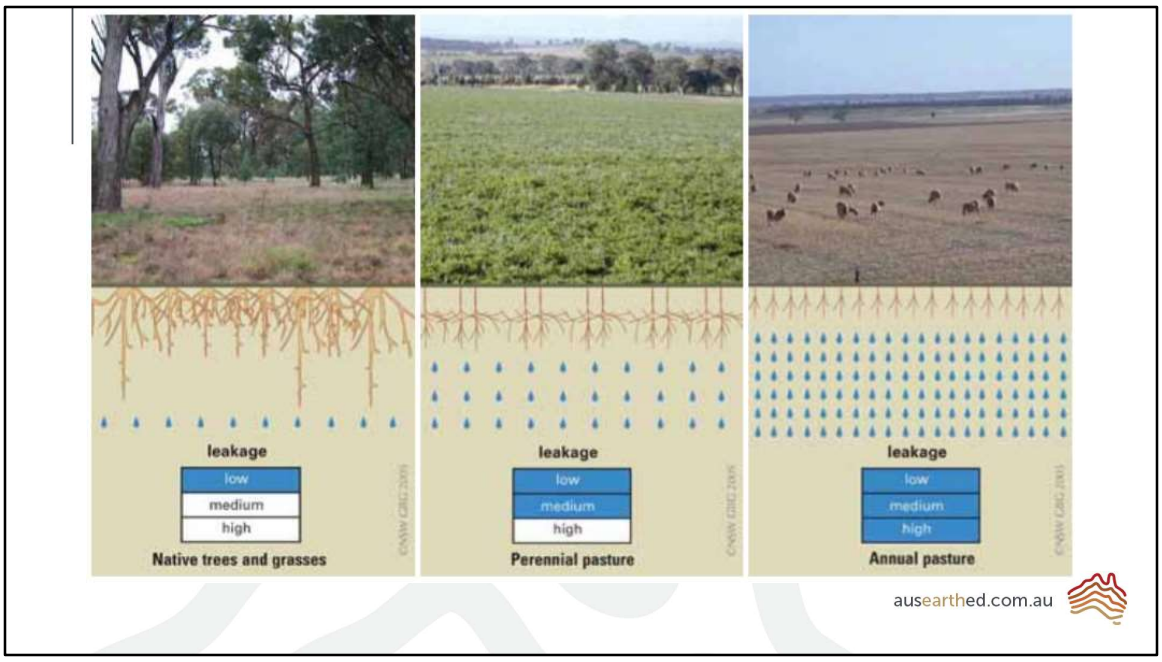
Dryland salinity is caused by land clearing
Irrigation salinity is caused by irrigation (usually in association with land clearing)
Urban salinity is that affecting the urban environment (similar to irrigation salinity in terms of water balance)



In all cases of soil salinity, the natural water table has risen due to an imbalance in water infiltration and evapotranspiration.

Dryland salinity occurs after land clearing. In natural landscapes, trees and deep-rooted perennial vegetation absorb most of that water from rainfall, keeping the water table low. After land clearing this is no longer the case.



This comparison shows how different types of land cover affect water infiltration. When land is cleared for crops and annual pasture grasses, a greater amount of water can infiltrate to the water table.

Irrigation salinity

- The addition of water from irrigation speeds up water table rise
- Usually accompanied by land clearing for agriculture

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Irrigation salinity is a major problem in many of Australia's irrigated cropping areas such as the Murray-Darling Basin. The land is usually cleared for cropping and then irrigated. This compounds the initial dryland salinity and accelerates water table rise.

Urban salinity

- Affects large areas of Western Sydney and Wagga Wagga
- Trees are cleared, surfaces sealed and grasses planted

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Urban salinity is a major issue in greater Sydney. The town of Wagga Wagga has been battling the problem since the 1970s when grass was noted to be dying off in the local showground. Urban salinity is caused by land clearing for houses and yards. The water imbalance is increased by runoff from sealed surfaces, watering of shallow-rooted grass, and leakage from pipes and stormwater systems. In Wagga Wagga the relative contribution to groundwater recharge is 22% rainfall, 47% leaky water pipes, 14% rubble pits, 12% leaky sewer pipes and 5% garden watering. (https://riverina-e.schools.nsw.gov.au/content/dam/doe/sws/schools/r/riverina-e/localcontent/salinitystudynotes.docx)

Effects of salinity

- Plant death

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Trees are the first plants affected by salinity because their roots reach deeper into the soil and encounter saline groundwater first. The first sign is die-off of leaves at the crown of the tree. Eventually the entire tree dies.

Salt kills plants in two main ways.

1. Excess salt around the plant causes plant cells to dry out via osmosis. The water in the plant is less salty than ground water, so it moves out of the plant into the soil. In less extreme salinity, the plant cannot absorb water efficiently because of the salt gradient, so growth is slowed.
2. Excess sodium and chloride ions are toxic to plants. They can cause burning and yellowing of leaves.

Effects of salinity

- Erosion

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Salts affect soil structure, making it dry and crumbly. Vegetation has died and there are no longer deep roots to hold the soil together. These factors leave the soil highly vulnerable to erosion.

Effects of salinity

- Crumbling infrastructure

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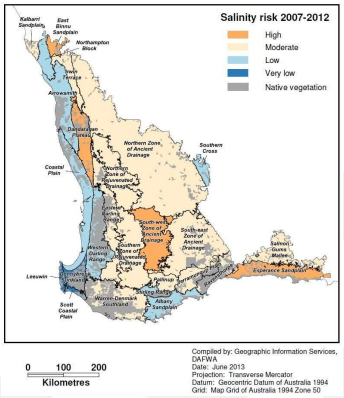
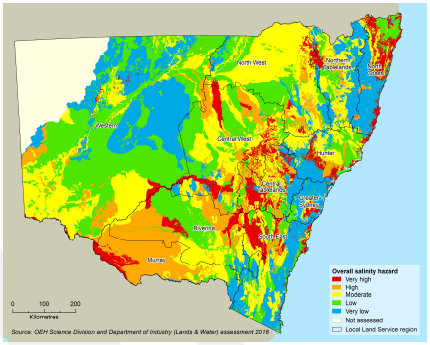
You can see the crumbling concrete foundations on this explosives depot which was built on saline soil. Salt causes concrete, bitumen and brick to crack and crumble, drastically reducing the lifespan of building materials and the built environment.

Extent of the problem

- Expected to increase from 5.7 million hectares in 2001 to 17 million hectares by 2050





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Soil salinity is a major problem across Australia, affecting agricultural regions in Western Australia (map on left) and NSW (map on right).

The Western Australia government estimates that salinity results in $519 million of lost agricultural productivity every year. (https://www.agric.wa.gov.au/soil-salinity/dryland-salinity-western-australia-0)

In NSW in 2000 it was estimated that (https://www.environment.nsw.gov.au/resources/salinity/quickguide.pdf):

- Dryland salinity affected approximately 150 000 hectares of land
- Irrigation salinity affected 320 000 of land (15% of irrigated land, with 65% under threat of being affected)
- Urban salinity/ high water table affected 34% of State roads

The costs of urban salinity may exceed those of agriculture. Salinity cause underground pipes to fail, houses to crumble and roads to crack. Road damage in south-west NSW alone is estimated at $9 million. Local councils in these areas spend more than 80% of their salinity repair budget on fixing roads and bridges. The lifespan of roads is cut by half in areas of urban salinity.

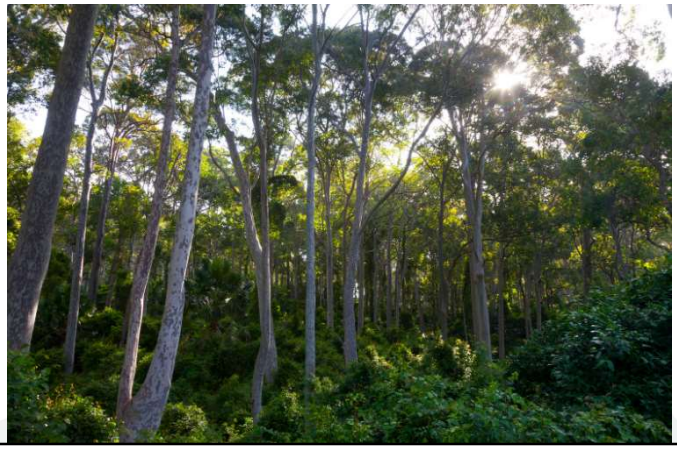
(https://www.aph.gov.au/parliamentary_business/committees/senate/environment_and_communications/completed_inquiries/2004-07/salinity/report/c06)

Despite known risks of salinity, development continues in areas of western Sydney with high salinity danger.

Figures on dryland salinity are from the 2016 Australian State of the Environment report: https://soe.environment.gov.au/theme/land/topic/2016/soil-salinity-and-acidification

Solutions

Must address the excess water infiltration



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Restoring a natural water balance is crucial. Planting deep-rooted native trees is our favourite strategy in EES, but it is not a suitable strategy for many locations. We cannot cover Australia in native bushland whilst still having space for cities, industry and agriculture.

Strategic use of vegetation – trees on hills

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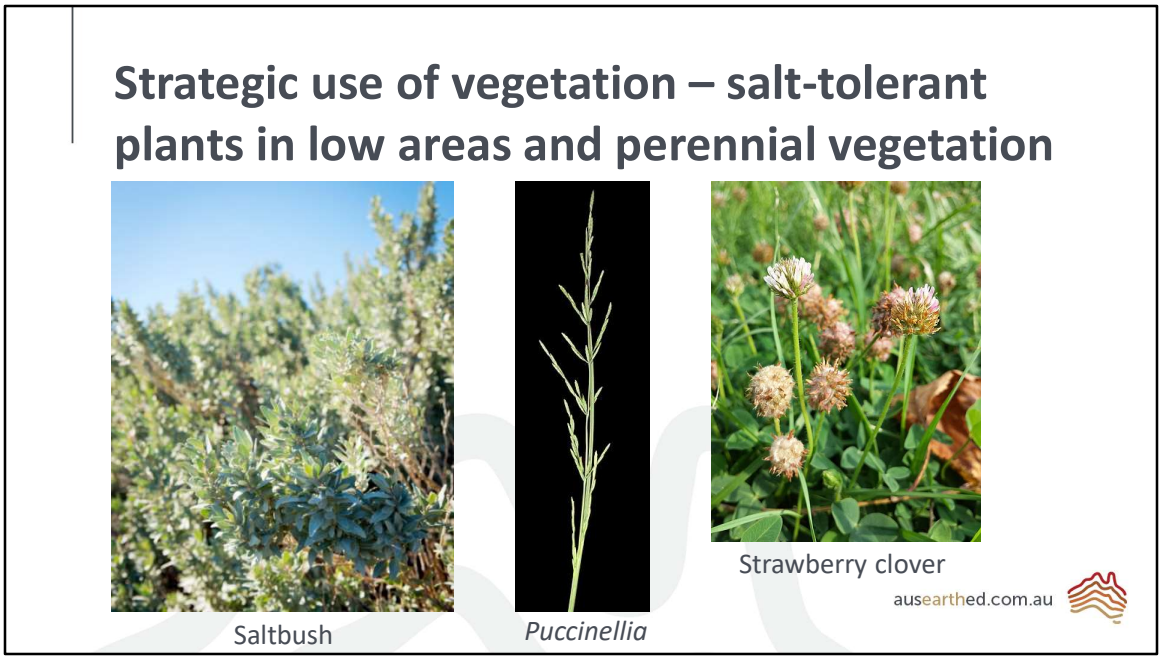
As the water tables rises and mobilises salts, low-lying areas are the first affected. They become boggy and salty. Most plants will not grow in boggy, saline-affected areas, so tree planting is best done on hilltops. Trees can establish in these locations and absorb large quantities of water that would otherwise add to the excess groundwater.

The best configurations are block planning (often on top of a hill) and alleys between paddocks and/or across hills.
https://www.environment.nsw.gov.au/resources/salinity/economicbenefitsandcostsoftreeplantingforsalinitycontrol.pdf



Salt-tolerant grasses and shrubs can be planted in boggy low-lying areas to prevent erosion, offer forage for grazing animals and absorb excess water. Options include saltbush as a shrub and a mixture of *Puccinellia*, tall wheatgrass and strawberry clover for pasture. Strawberry clover is a legume, so helps fix nitrogen to improve plant growth.

All of these species are perennial plants. This means they develop longer root systems that absorb relatively more of the rainwater recharge. Perennial pastures are particularly important in salinity-affected aeas.

Water-efficient irrigation tailored to soil type

Best for heavy clay soils

Best for permeable soils

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Irrigation is only a problem if more water is applied than the plants use. Thus, knowledge of plant requirements and soil structure is vital when selecting and using an irrigation system. Areas with highly permeable soil may be unsuitable for irrigation.

Sensors that monitor water content in the soil can be used to turn off irrigation when water reaches the desired root level. In general, if soil is permeable, a spray or trickle system will be the best irrigation choice. For heavy clay soils, field levelling and furrow irrigation is more appropriate.

Subsurface drainage systems can help to manage excess water, storing it for later or allowing it to drain away in local waterways after heavy rain.

Learn more: https://www.publications.qld.gov.au/dataset/salinity-management-handbook/resource/2d11badb-5e55-43e5-8811-042fc84c9d9d

Salt in the city

- Plant trees
- Avoid overwatering
- Native gardens
- Replace leaky pipes

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Councils and residents can combat urban salinity in a number of ways including planting large native trees and shrubs in public spaces, avoiding overwatering of parks and homes, encouraging the use of native gardens with low water requirements and replacing leaky pipes for water and sewage.

Dewatering bores

- Extract saline groundwater and release to:
  - Local waterways
  - Evaporation basins

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In extreme cases of high groundwater, dewatering bores may be installed. These are used to pump groundwater into local waterways or into evaporation basins. Although dewatering bores effectively lower the water table, they require electricity to run and construction of drainage channels or pipes for the water can be costly. In addition, saline water is added into freshwater ecosystems or salt from evaporation must be disposed of – often in landfill. Dewatering bores in Wagga Wagga discharged into the Murrumbidgee River.

Image sources

Images not listed below are from the AusEarthEd collection or are licensed for use

- Causes of dryland salinity from Slinger & Tension 2007, *Salinity Glove Box Guide: NSW Murray & Murrumbidgee Catchments,* NSW Department of Primary Industries
- Eromanga Sea from Oz fossils, ABC Science
- Lake Eyre drainage basin by K Musser 2010, Creative Commons
- Leakage comparison between vegetation types on similar landscapes from Slinger & Tension 2007, *Salinity Glove Box Guide: NSW Murray & Murrumbidgee Catchments,* NSW Department of Primary Industries
- *Puccinellia* by K Thiele 2012, Creative Commons
- Salinity affected area, 2013, from CSIRO Science Image
- Salinity hazard assessment for NSW, 2017, from OEH Science Division and Department of Industry (Lands & Water) assessment 2018
- Salinity risk map for the south-west agricultural region (WA), Geographic Information Services, DAFWA 2013
- Salt weathering of building stone by S M MacLeod 2005, public domain
- Salt weathering of foundations of Dry Creek explosives depot by Bahudhara 2015, Creative Commons
- Soil erosion caused by high salinity in the ACT 2003, from CSIRO Science Image
- Strawberry clover (*Trifolium fragiferum*) by S Iefnaer 2018, Creative Commons

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