Soil and groundwater acidification on the Gnangara Mound

Overview

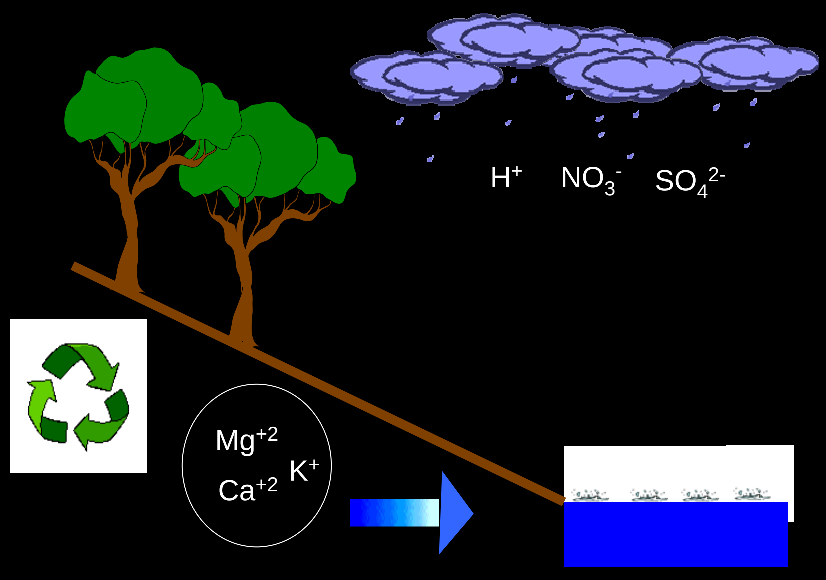
- **Causes and impacts of acidification**
- **Outline recent investigation program**

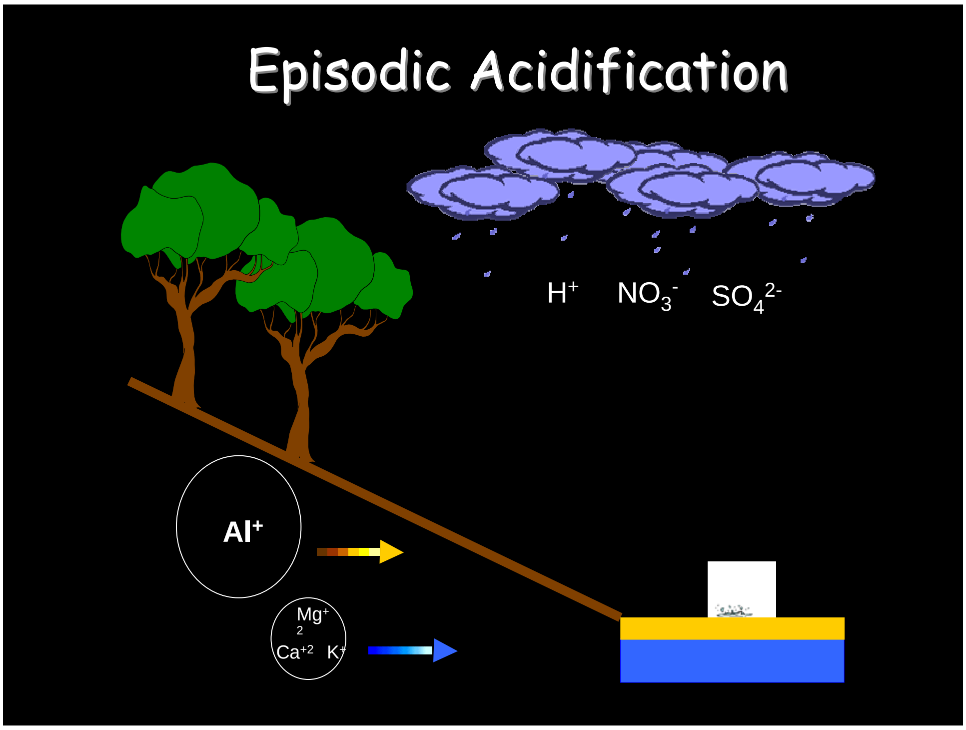
- **Potential management issues**

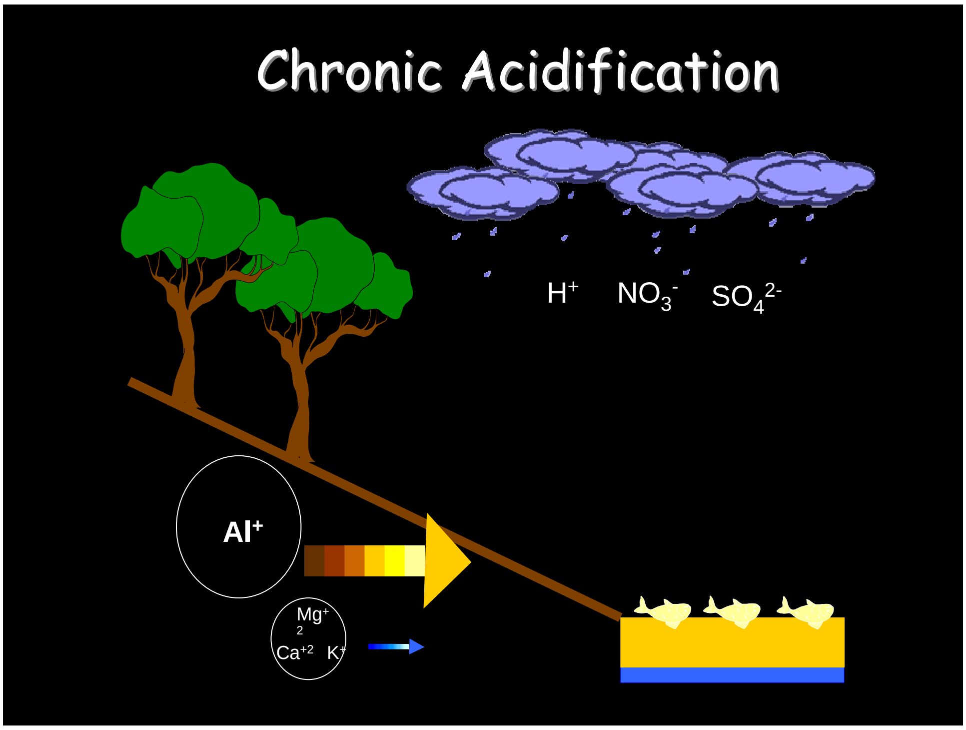
What is acidification?

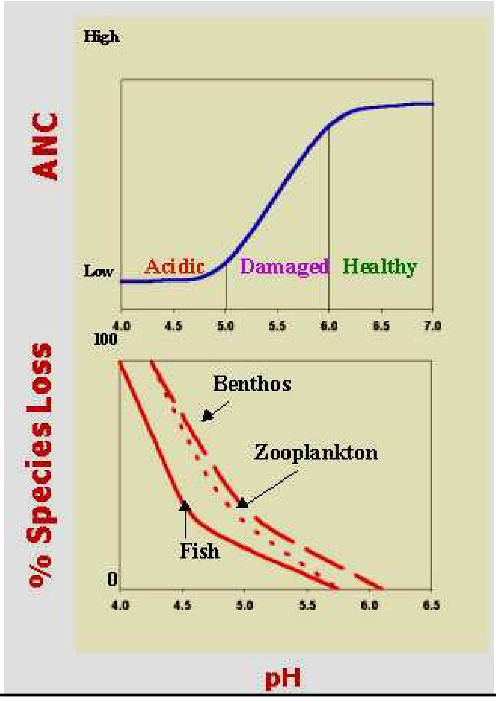
- Change in soil and water chemistry triggered by increased input of hydrogen ions;
- Increases solubility of metals (particularly iron and aluminium) – highly toxic to aquatic fauna, flora
- Release of arsenic, cadmium other toxicants
- Loss of nutrients, organic matter, “base cations” from soil – progressive decline of ecosystems
- Large economic impacts – damage to infrastructure, loss of fisheries, decline of agricultural productivity

Base Cation Depletion




Episodic Acidification
H+
NO3-
SO4 2-
Al+
Mg+2
Ca+2
K+


Chronic Acidification
H+
NO3-
SO4 2-
Al+
Mg+2
Ca+2
K+



Impact of acidification on wetland ecosystems

Acidification impacts on forests and woodlands – tree dieback and loss of sensitive species

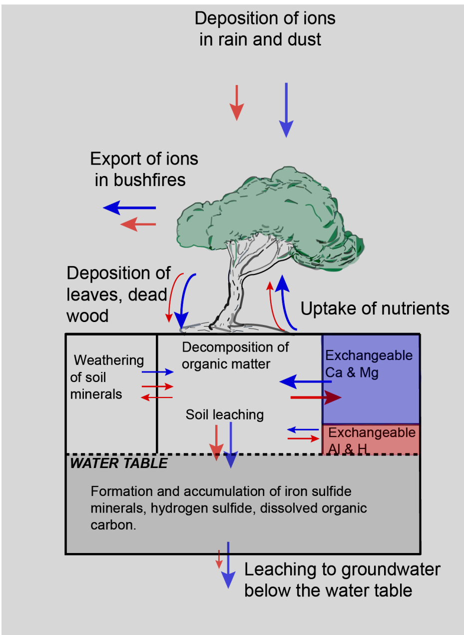
Loss of sensitive fauna – e.g. loss of wood thrush in NE USA linked to acidification (Cornell Uni research)

Sources of acid

- Sulfide minerals in soil – especially pyrite (VERY LARGE ACID INPUT) **(Acid sulfate soils)**
- Oxidation of organic matter
- Agricultural land use – excessive fertiliser use, high stocking rates, crop harvesting, timber plantations **(In WA this is a major concern because of losses to agricultural productivity)**
- Air pollution – sulfur and nitrogen oxides from industry, power generation, vehicle exhausts **(Acid rain)**

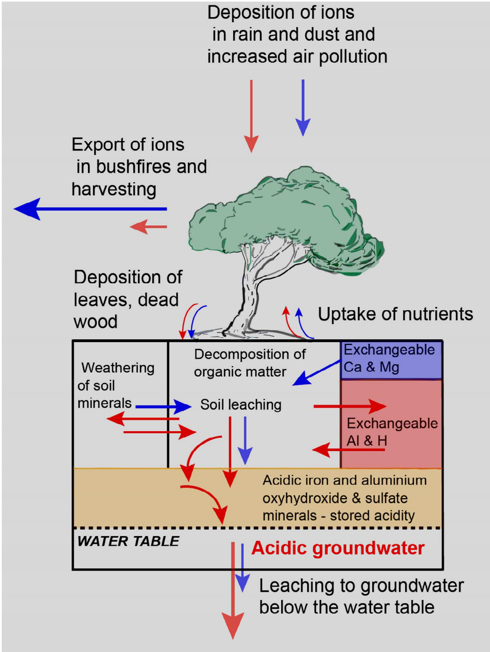
Soils do not care about acid sources – environmental impacts are the same

To properly assess acidification risks, must consider how soils are linked to the external environment



Conceptual model

Acid-base balance before European settlement

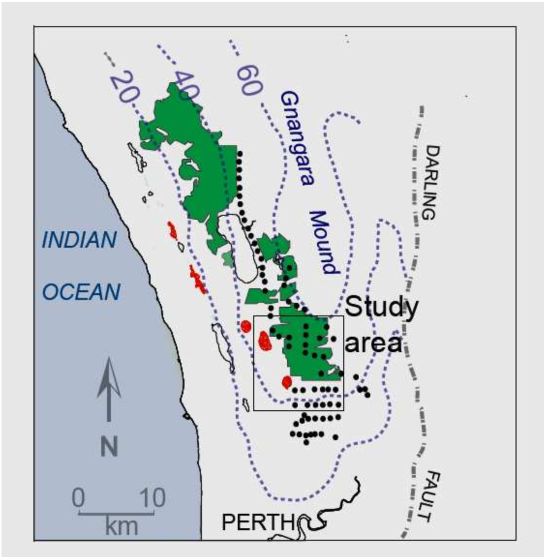


Conceptual model

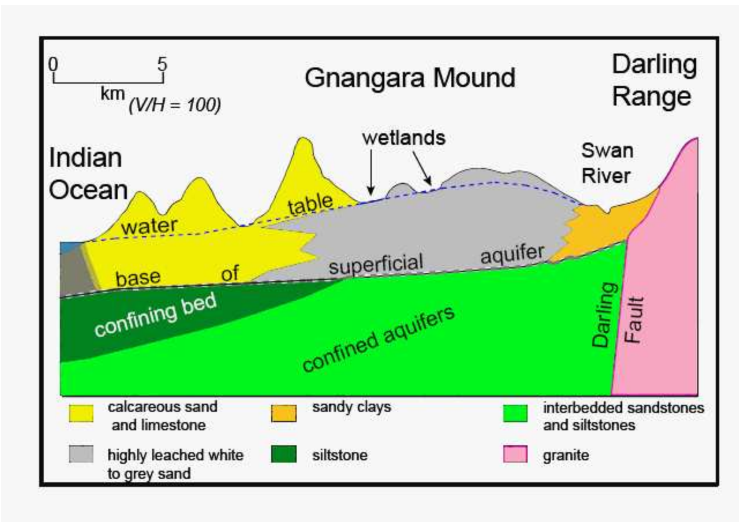
Acid-base balance after European settlement

Evidence that the acid-base balance is being disrupted on the Gnangara Mound

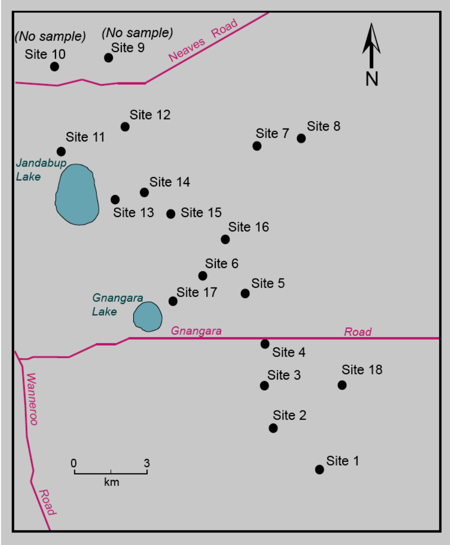
Investigation area – acidified wetlands shown in red, pines in green

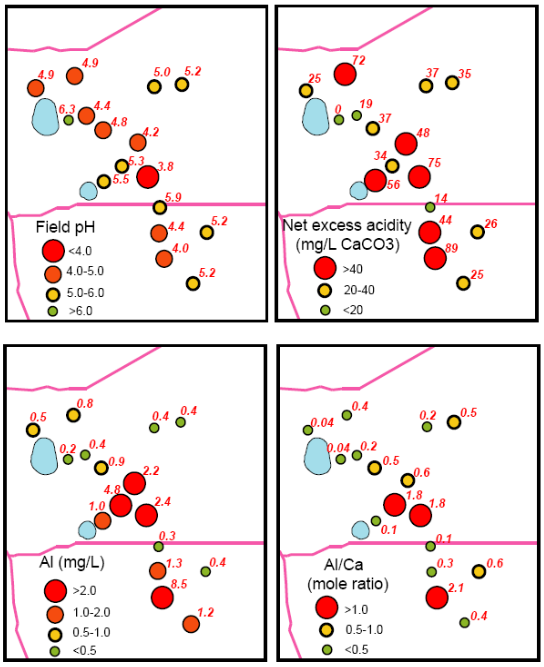


Investigations were focussed on Bassendean Sands (grey area)

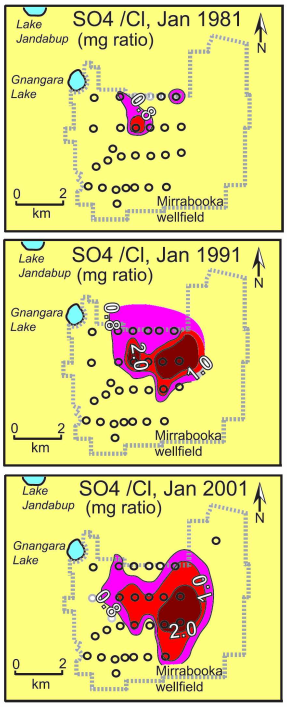


Drilling was carried out at 18 sites – groundwater, some soil sampling

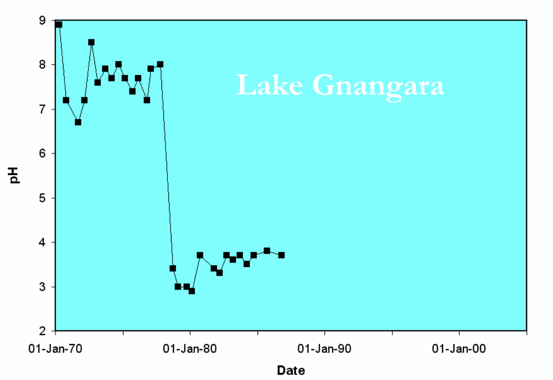




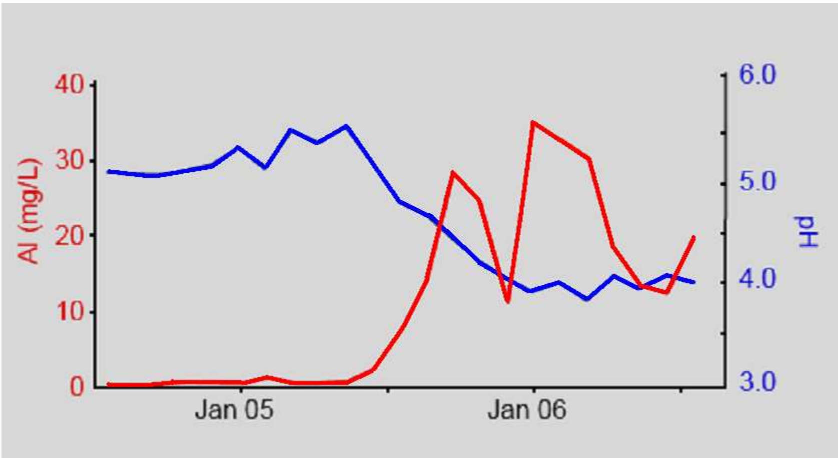
Indicators of groundwater acidity at the water table



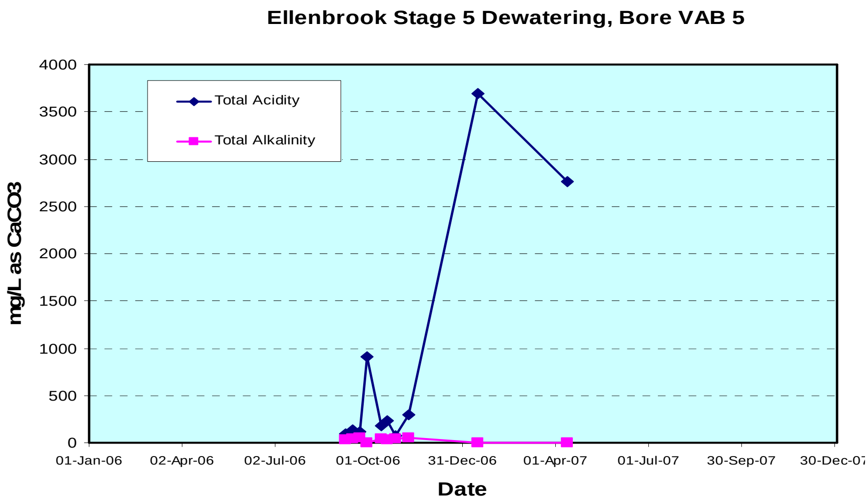
Indicators of acidity changes over the last 25-35 years in the area



Indicators of recent acidity changes – water quality in Lake Mariginiup (Troy Cook data)



Indicators of recent acidity changes – soil excavation and dewatering for urban development



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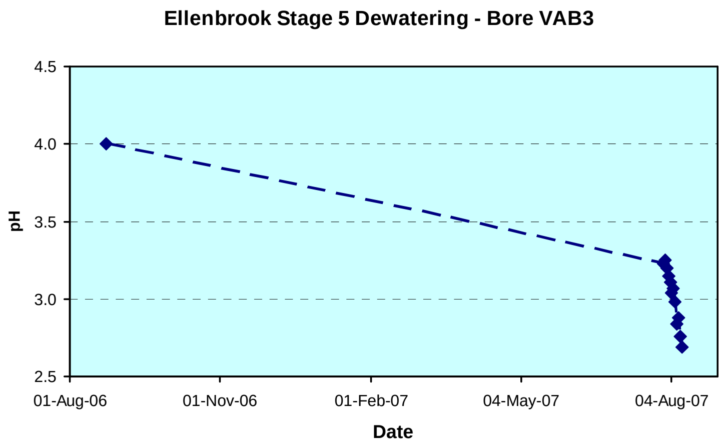
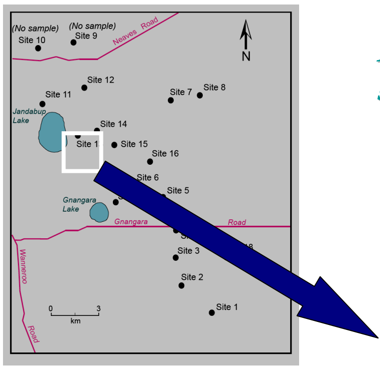
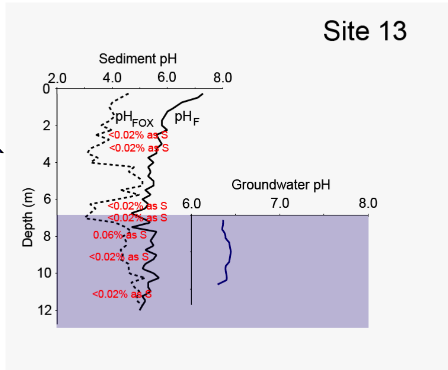


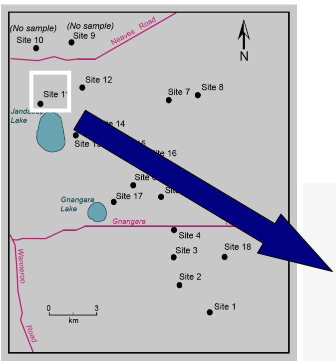
Variation of soil, groundwater acidity with depth – site 13



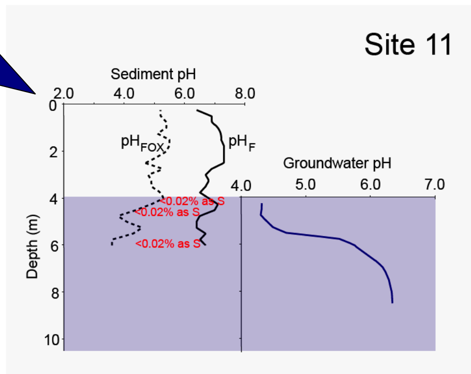
Bushland - low acidity, but subsoil starting to acidify?



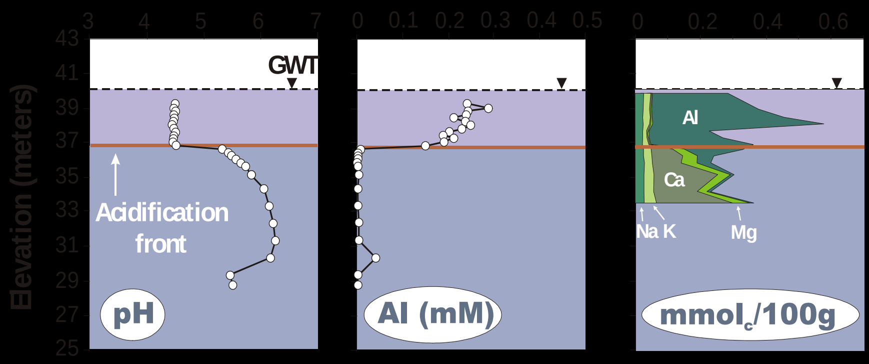
Variation of soil, groundwater acidity with depth – site 11



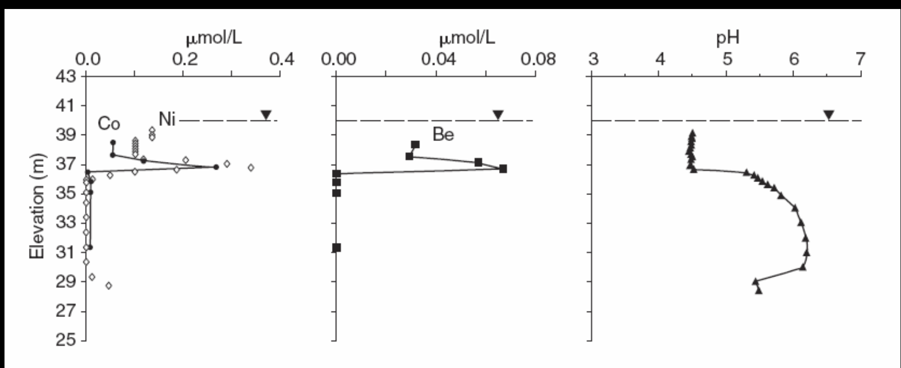
Rural land use, encroaching urban – presence of clear acidification front in groundwater



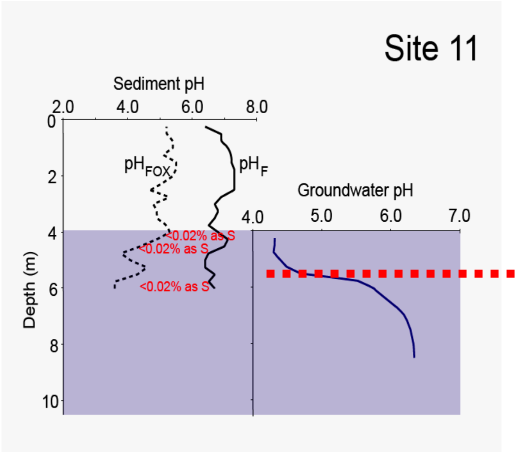
Acidification front in a sandy aquifer in Denmark (source: Prof Dieke Postma)



Elevated metal concentrations in groundwater at an acidification front in Grinsted, Denmark (source: Prof Dieke Postma)



Metal concentrations in groundwater at the acidification front, site 11



Cu = 65 µg/L

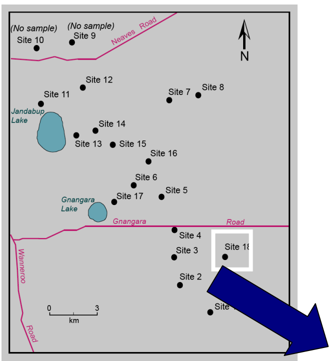
Pb = 12 µg/L

Ni = 26 µg/L

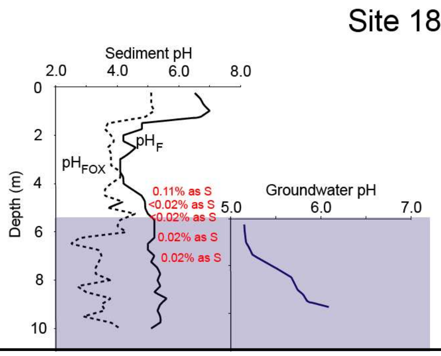
Zn = 82 µg/L

(up to 10 times background levels for the area)

Variation of soil, groundwater acidity with depth – site 18

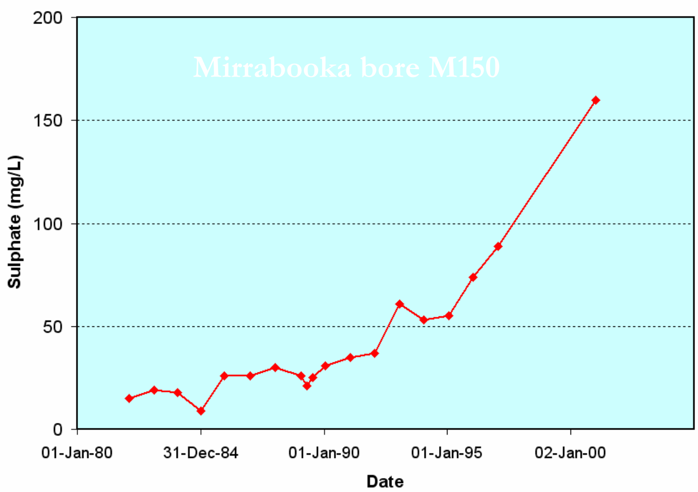


Mirrabooka borefield (Whiteman Park) –subsoil has acidified due to water table drawdown, groundwater acidification front present

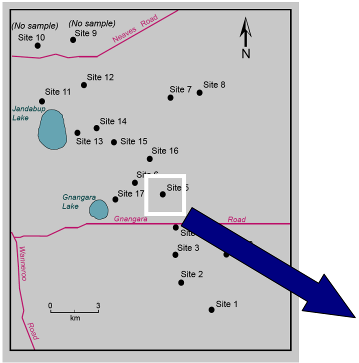


Production bore data indicate base cations being leached from soils in this area…

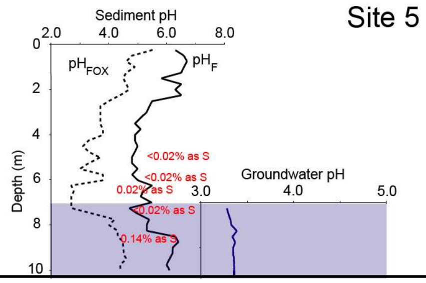
…and sulphur



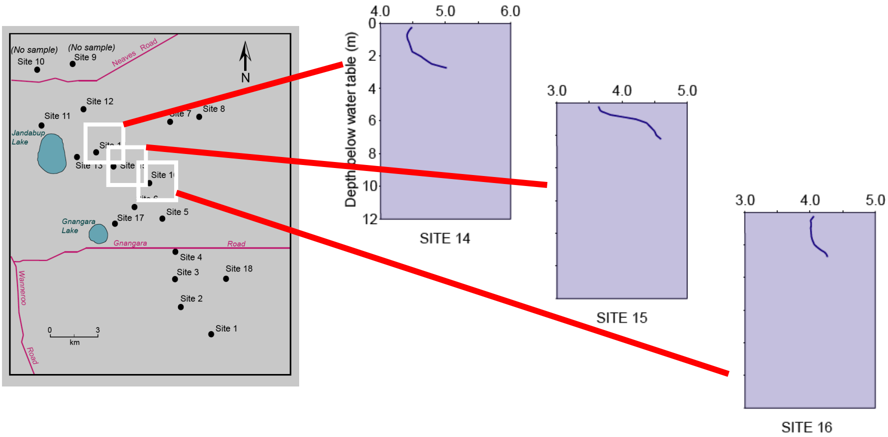
Variation of soil, groundwater acidity with depth – site 5



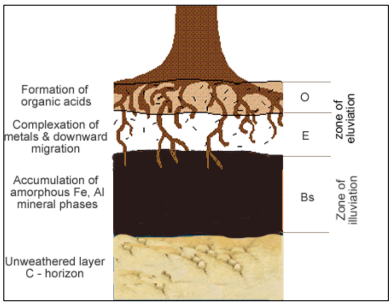
Pine plantation within cone of depression of Mirrabooka borefield– subsoil is acidifying, very acidic groundwater, deep acidification front due to drawdown - role of podzols?



Other groundwater pH profiles beneath pines

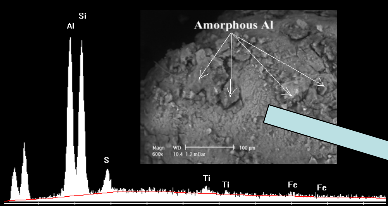


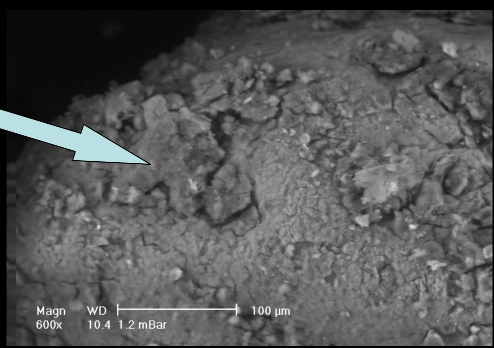
Podzols beneath the Gnangara pine plantations (Troy Cook's PhD work)



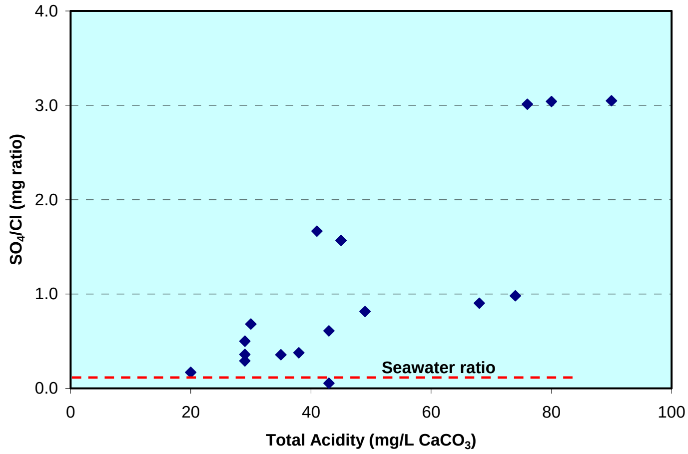
Podzols form from the mobilisation of Al and Fe from upper to lower soil horizons by organic acids leached from decomposing organic material. Organic acids mobilise Al from the E horizon as alumino-organic solutes and translocate to the B horizon. Atmospheric-derived SO_4^{2-} can also facilitate the transport of Al.

…SEM evidence of poorly crystalline Al phases in podsols that may be a source of soluble Al (Troy Cook's PhD work)

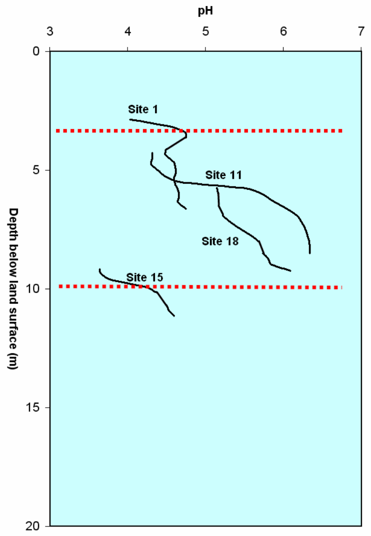


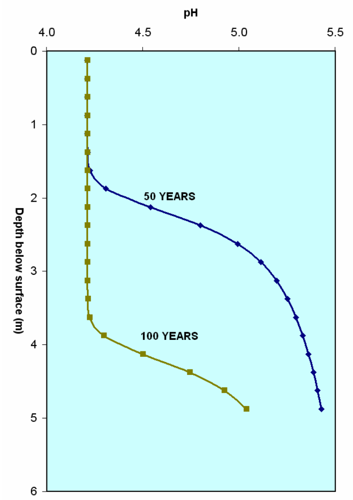


Increasing groundwater acidity also associated with increasing sulphate – but low levels of sulphides in sediments, low fertiliser use. Possible atmospheric input

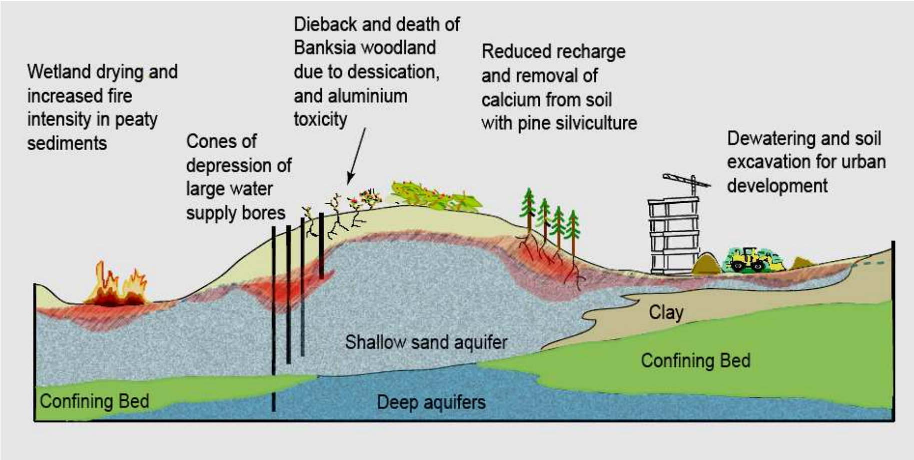


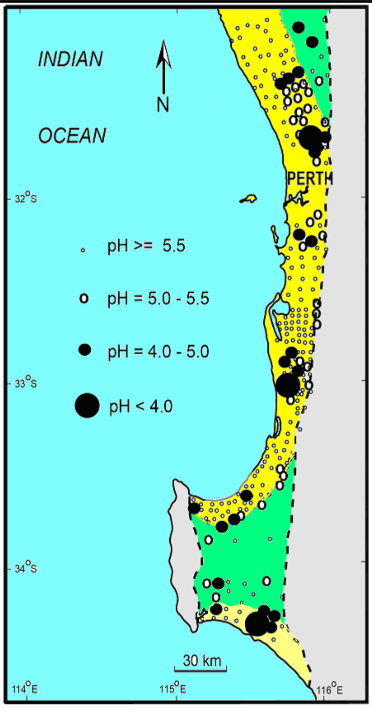
Preliminary modelling indicates that it would take about 50-100 years for acidification fronts to reach current depths –increased air pollution in 20th C a trigger?





Conceptual model





Acidification appears to be widespread on the Swan Coastal Plain

Apparent link to intense groundwater use

Potential management issues –abstraction for public water supply, horticulture

- **Continuing decline of water table elevation is likely to continue acid release, soil depletion – both wetland and woodland impacts likely**
- **Rapid rebound of the water table could mobilise stored acidity and metals and cause environmental impacts – i.e. care needed with pine clearing, vegetation thinning strategies**
- **Significant risk that increasing abstraction under low rainfall will cause widespread harm to both terrestrial, wetland ecosystems in the area.**

Potential management issue – domestic groundwater use

- **Ribbons of Blue testing of groundwater samples from land owners in Neaves Rd area indicated that many private bores tested have pH <4 –potential health issue if used untreated for potable use. Also potential damage to gardens, livestock**

Potential management issues – vegetation impacts

- **Reestablishing native vegetation in areas of high drawdown (Whiteman Park) may be difficult due to base cation depletion, Al toxicity**
- **Al toxicity is possibly a significant contributor to Banksia deaths in borefields – need to look at soil quality, not just soil moisture**
- **Risk of losing sensitive plant species and dependent fauna in woodlands in the area**

Potential management issue – new urban development

- **Soil excavation and construction dewatering could exacerbate acidity problems on Gnangara Mound – pattern observed on parts of the Jandakot Mound, Ellenbrook**

Potential management issues - wetlands

- **Likely that more wetlands will acidify on the Gnangara Mound under current groundwater abstraction regime, low rainfall**
- **Using groundwater to maintain acidified wetlands unlikely to be sustainable- acidification front moving into superficial aquifer**

Potential management issue – corrosion of infrastructure

Lake opposite Livingston shopping complex, Canning Vale

Potential management issue – corrosion of infrastructure