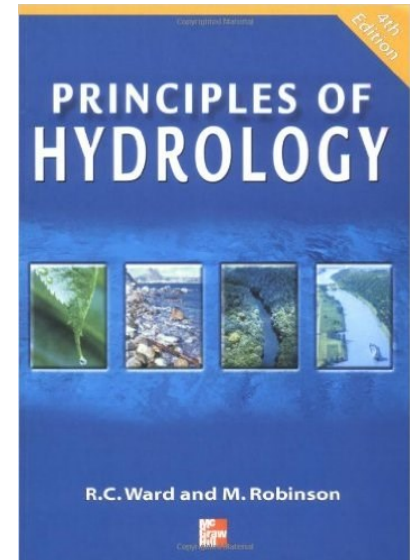
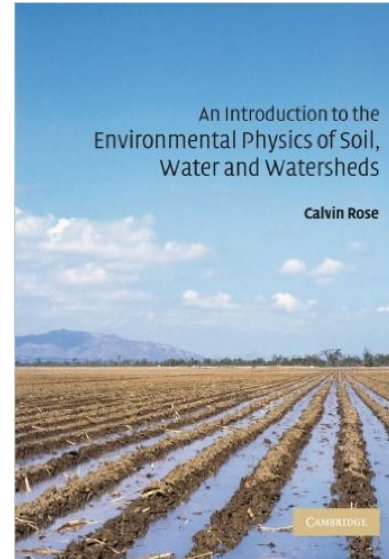


Soil Moisture

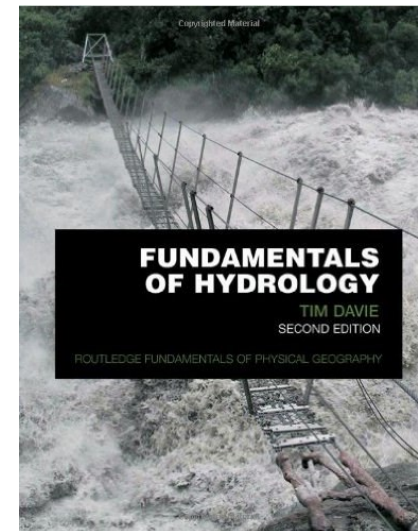
Prof. Kate Heal
School of GeoSciences

Soil, Water & Atmospheric Processes

Rose –
Chapter 11

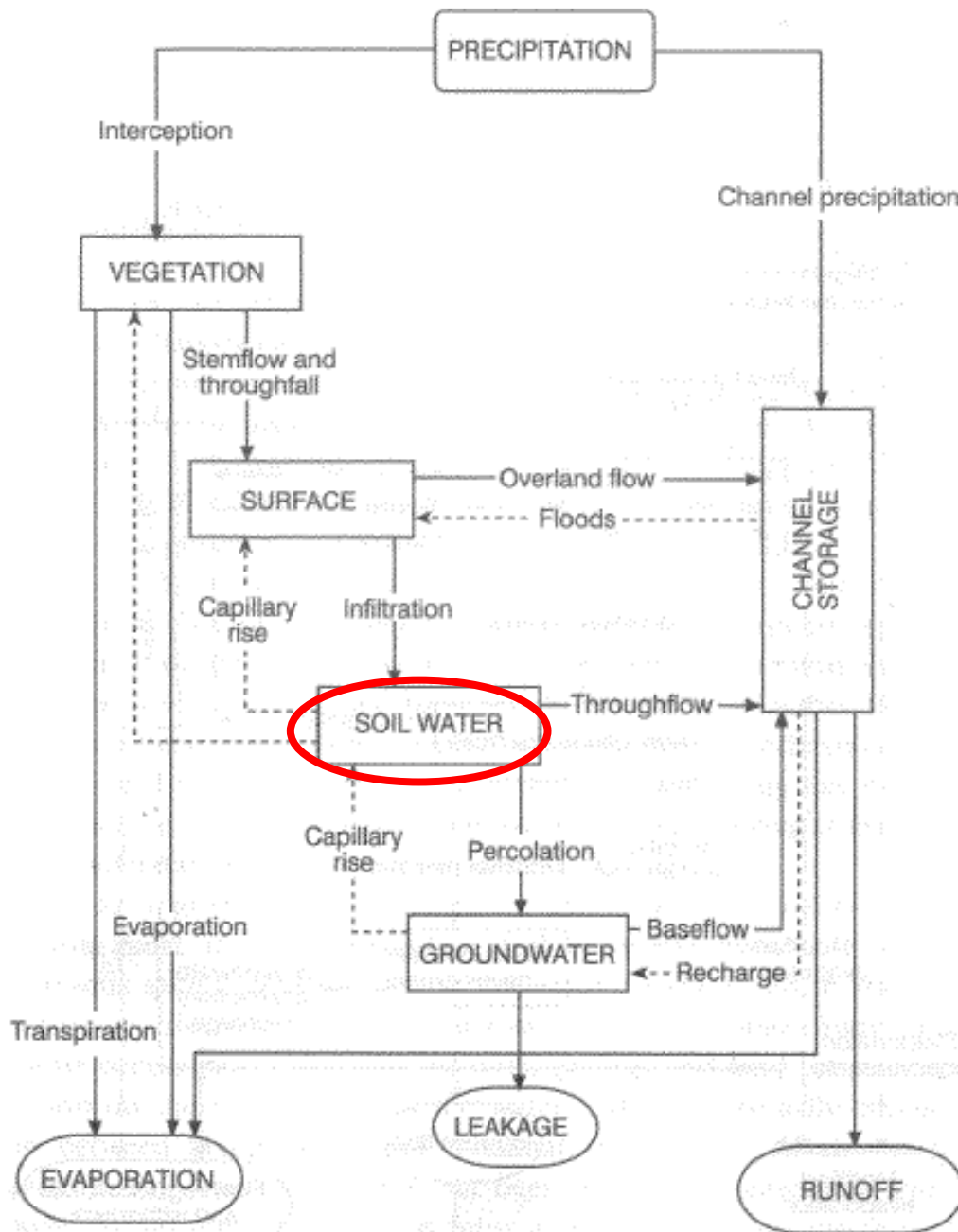


Ward & Robinson –
Soil Water chapter



Davie –
Storage chapter

Role of soil water in the catchment hydrological system



(Ward & Robinson, 2000)

Importance of soil moisture

- Major control of floods and droughts
- Groundwater recharge
- Water for vegetation and crops
- Movement and accumulation of pollutants



Nasa launches satellite to observe soil moisture

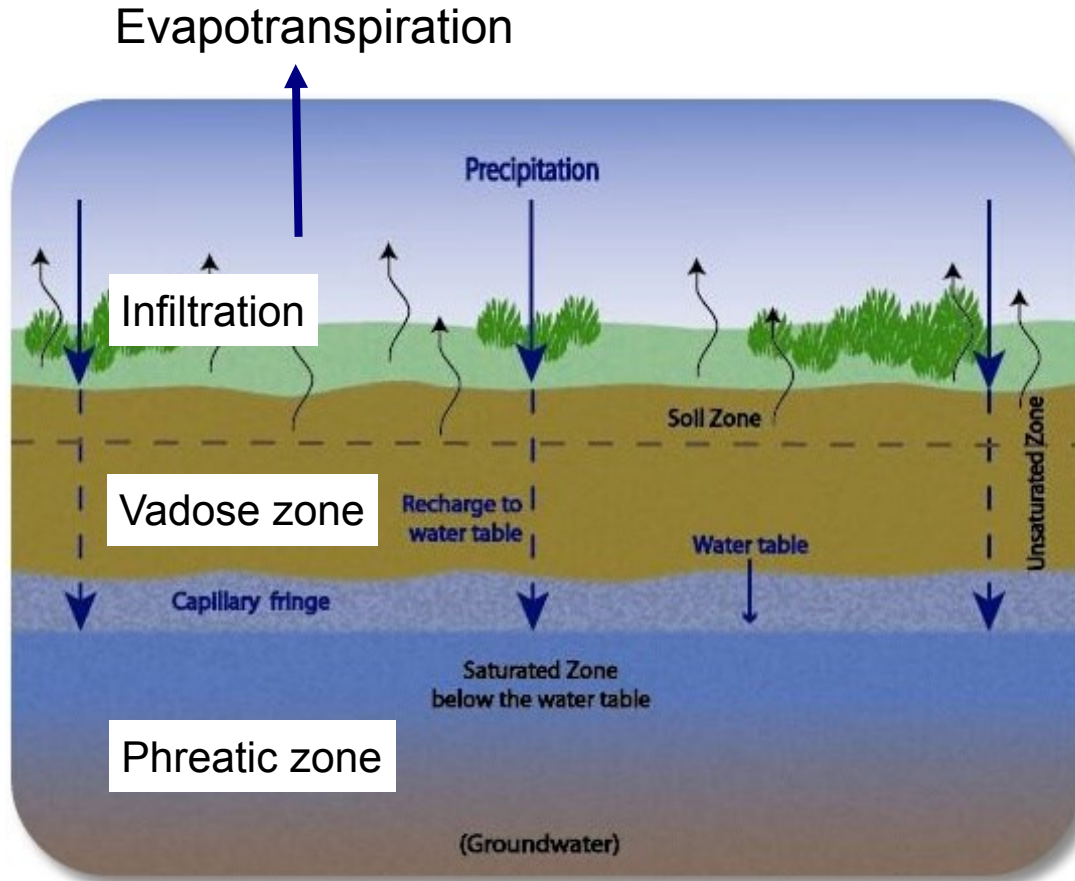
31 January 2015 Last updated at 18:29 GMT



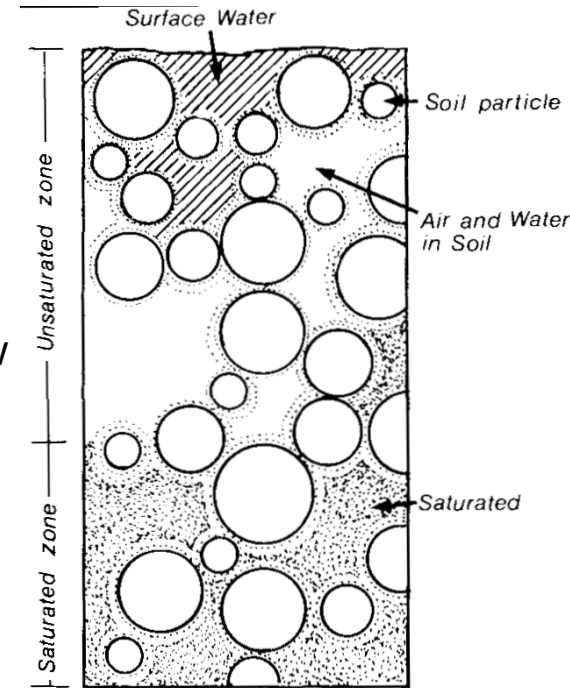
Lecture overview

- Soil water terminology
- Measuring soil water
- Soil water storage
- Soil water characteristics
- Soil water movement

Classification of subsurface water



Throughflow

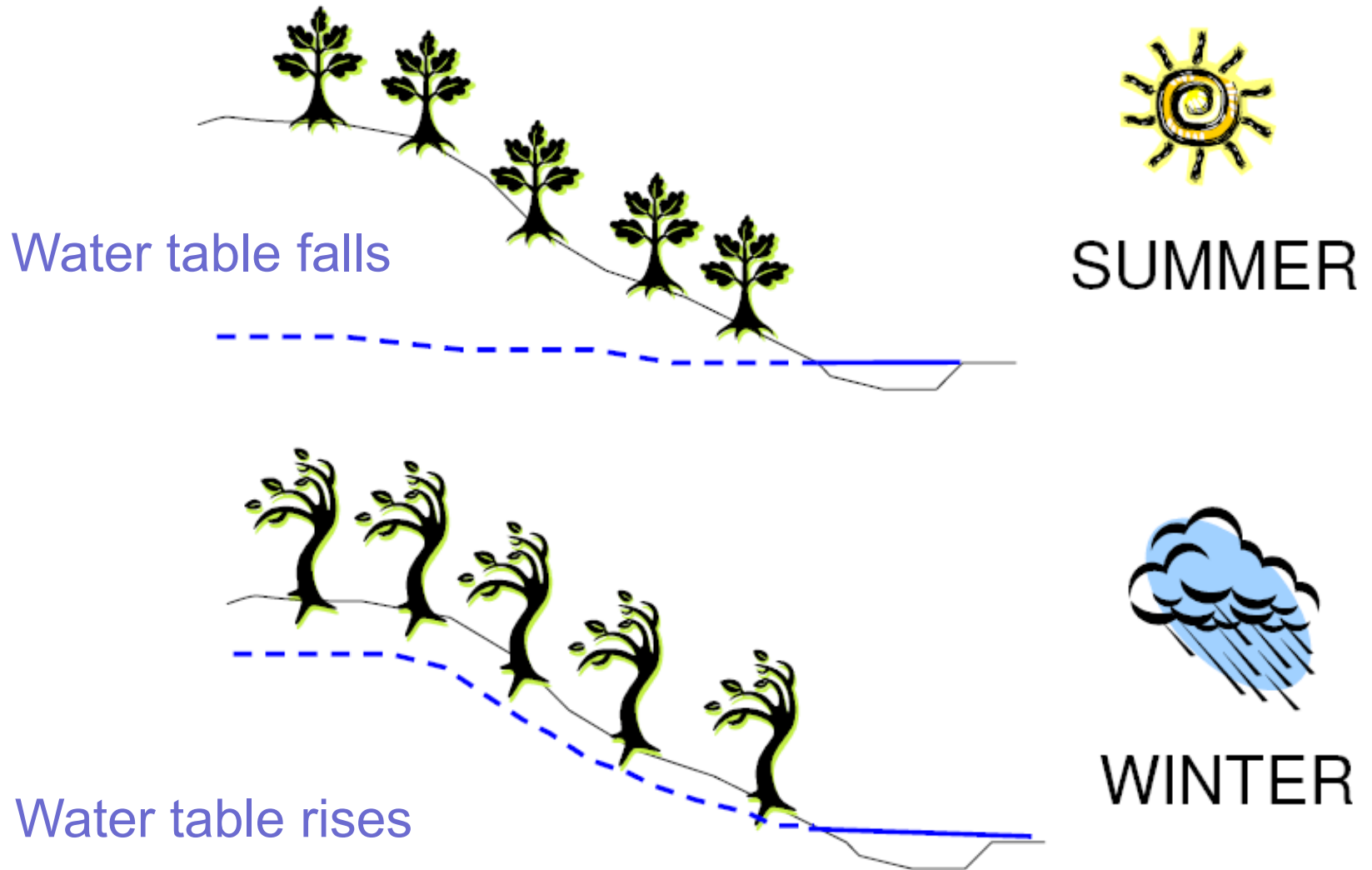


Soil water content is a continuum

(Newson, 1994)

http://www.dwa.gov.za/Groundwater/Groundwater_Dictionary/index.html?introduction_subsurface_water.htm

Soil water conditions vary in time and space



Measurement of soil moisture content

Direct measurement (gravimetric)

$$\% \text{ soil moisture} = \frac{\text{fresh weight} - \text{dried weight}}{\text{fresh weight}} \times 100$$

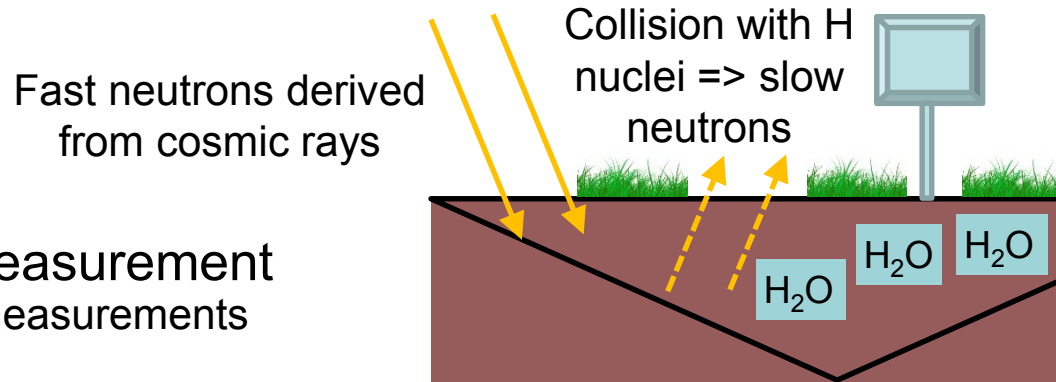
Indirect measurement

- Soil permittivity related to its volumetric moisture content (relative permittivity = ~80 for water, 1 for air, ~4 for soil)
- Measured by soil effect on electromagnetic field transmitted by a probe
- Can be used for continuous monitoring



New ways of measuring soil moisture content – cosmic ray neutron sensors

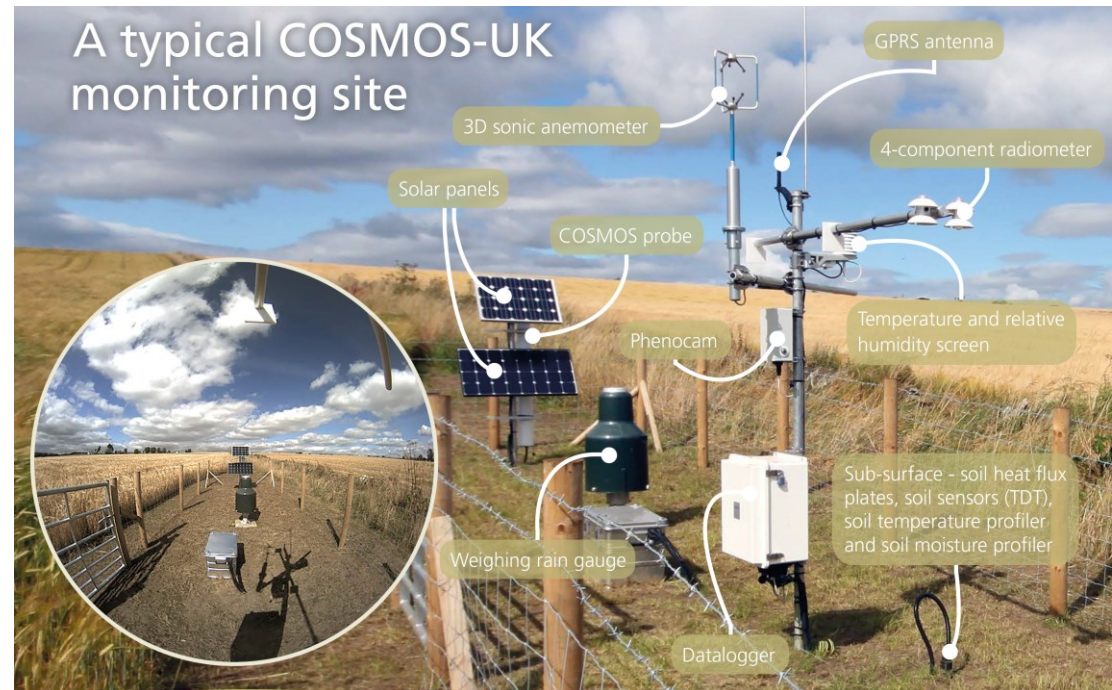
Sensor measures equilibrium concentration of fast neutrons



- Integrated measurement
 - avoids point measurements problems
- Applications include:
 - Flood forecasting
 - Drought monitoring
 - Groundwater recharge
 - Agronomy
- COSMOS-UK soil moisture network
 - 31 sites
 - Local calibration required using gravimetric soil moisture measurements to take account of location and soil chemistry

Footprint

Max. 700 m diameter, 0.7 m depth



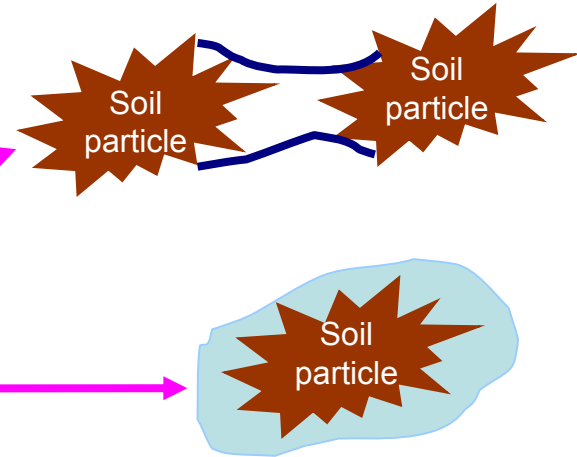
Balruddery Farm, near Dundee

Soil water forces

1. Osmotic forces

2. Capillary forces

3. Adsorption forces



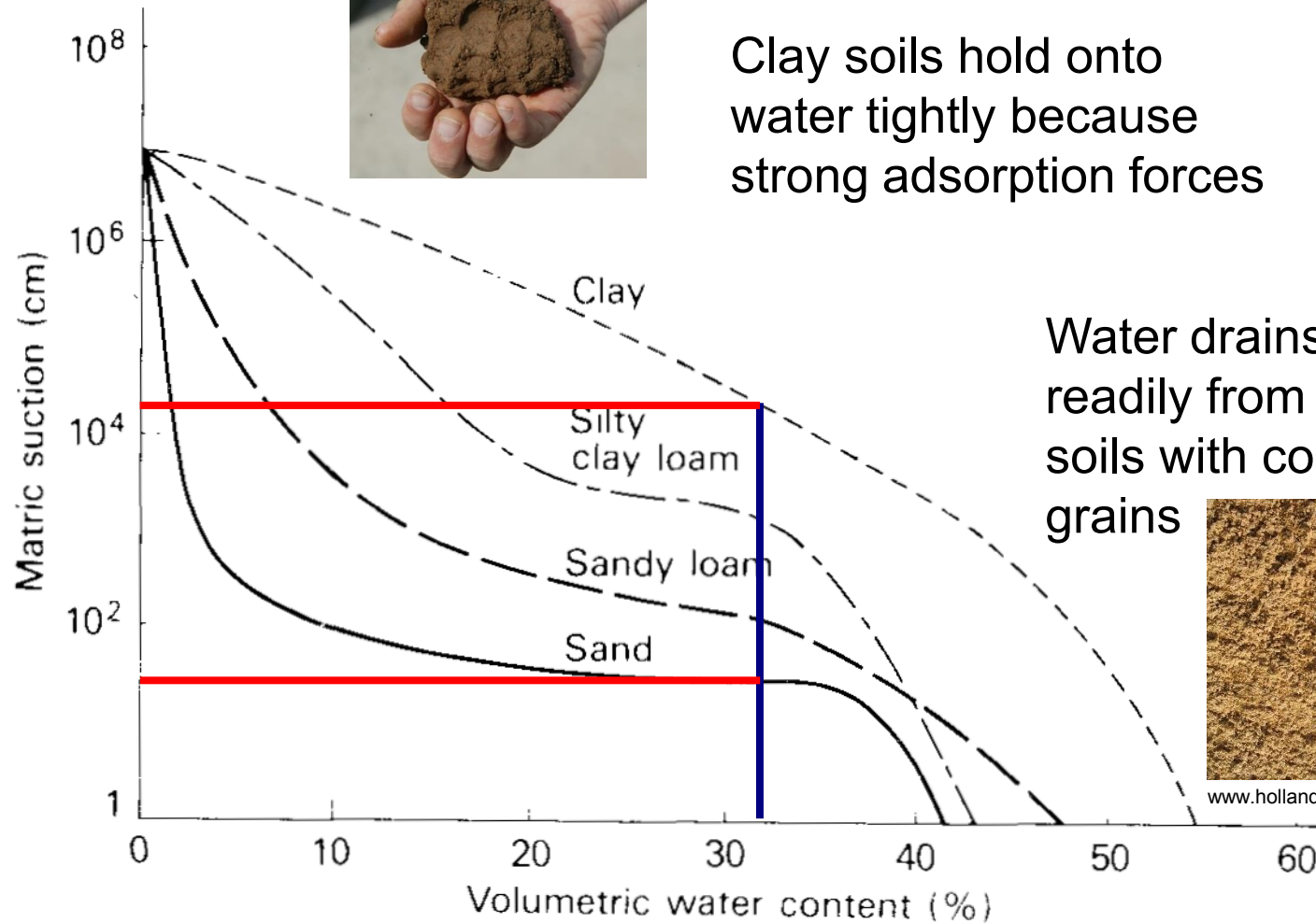
- Matric forces = capillary forces + adsorption forces
- Exert a TENSION or SUCTION

Soil moisture characteristics

www.junglemusic.net



Clay soils hold onto water tightly because strong adsorption forces



Water drains readily from sandy soils with coarser grains



www.hollandmulch.com

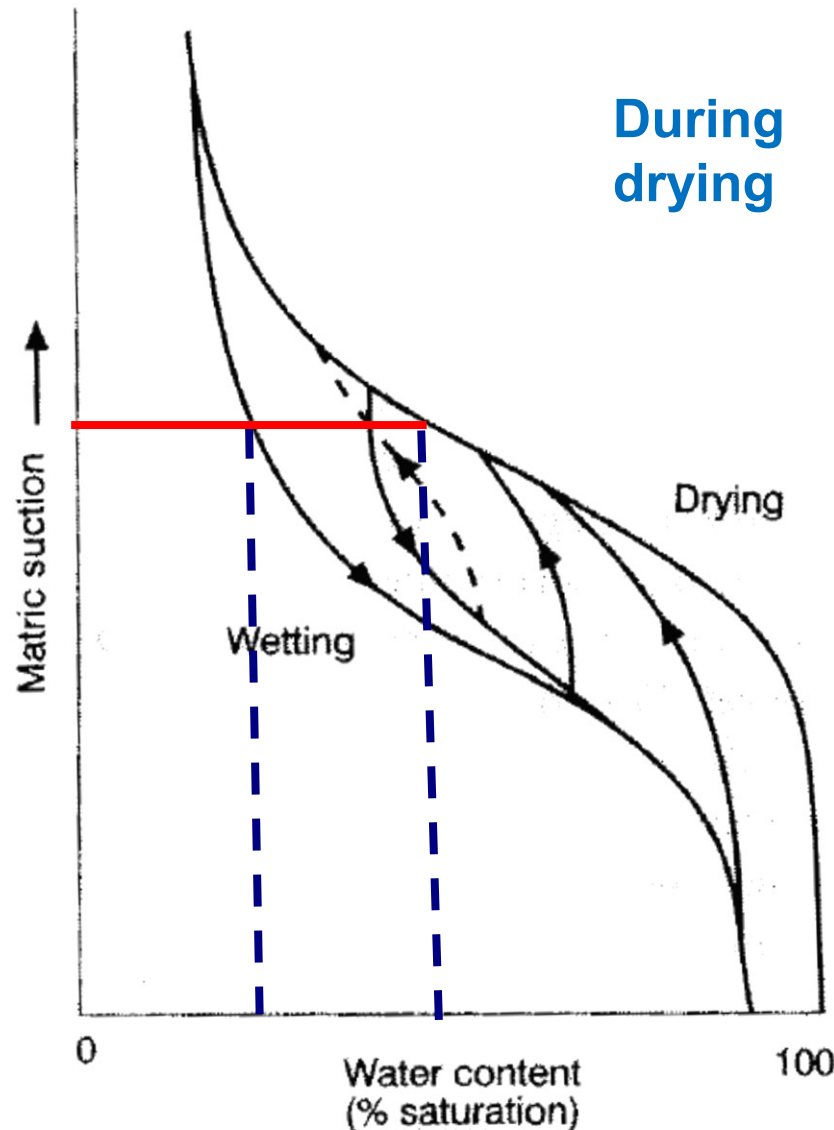
(Ward & Robinson, 1999)

Hysteresis in soil moisture characteristics

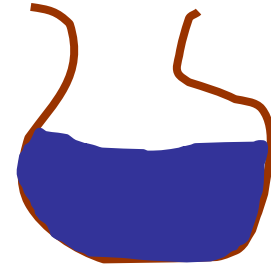
*“Hysteresis is the dependence of a system on its history” –
from the ancient Greek word meaning “lagging behind”*

At any
suction value,
drying soil
always
contains
more water
than wetting
soil

(Ward &
Robinson, 2000)



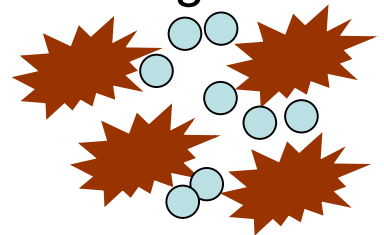
**During
drying**



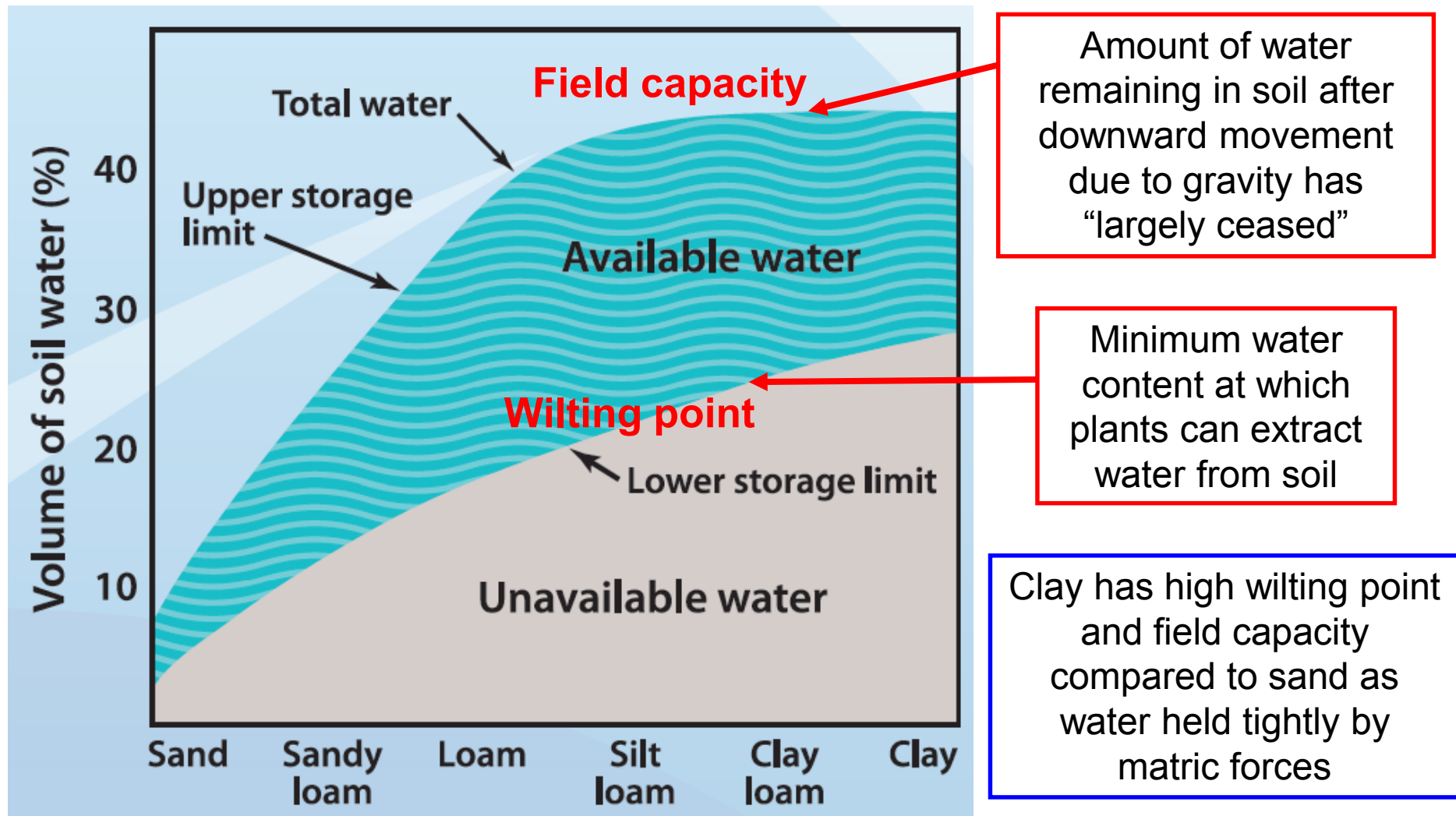
“ink bottle”
effect

During wetting

air trapped in
wetting soil



Soil moisture constants

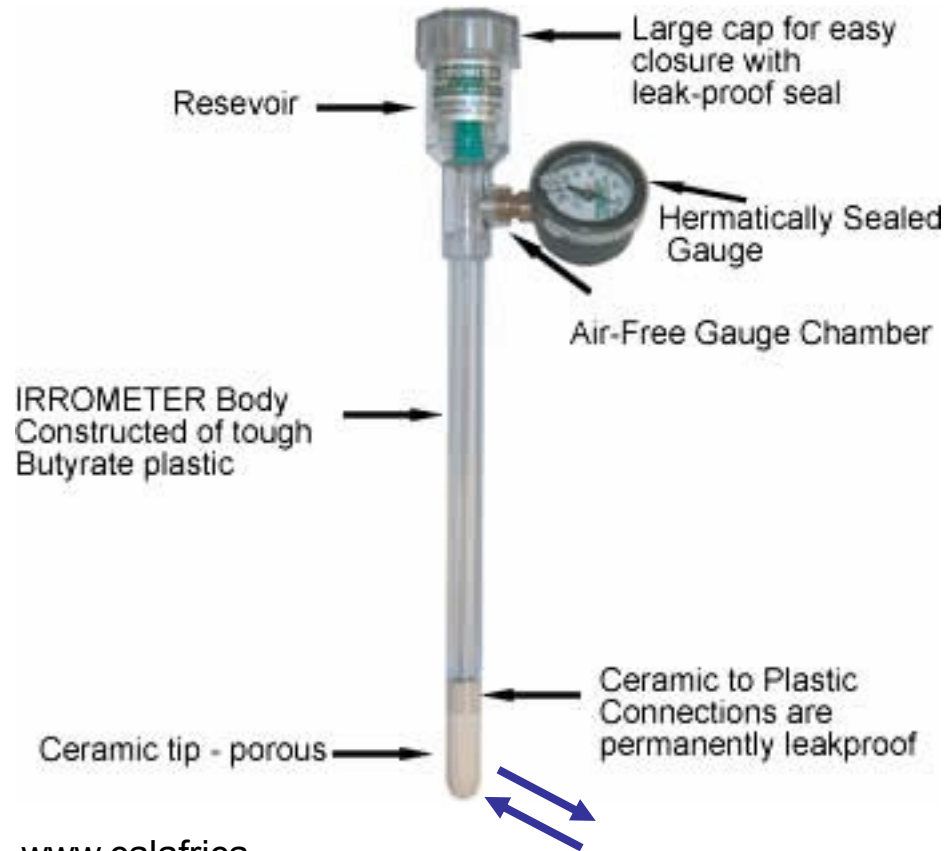


(<https://s3.amazonaws.com/soilquality-production/>)

Soil water movement

- Kinetic energy
- Potential energy
- Total soil water potential energy Φ =
gravitational potential energy Ψ_g + matric
potential energy Ψ_p
- e.g. if $\Psi_g = 0.6$ m and $\Psi_p = -0.2$ m, what is Φ ?

Measuring soil water matrix potential: tensiometers



www.calafrica-sa.co.za/images/

Water flows between soil and cup until pressure potential in cup equals that of the soil water

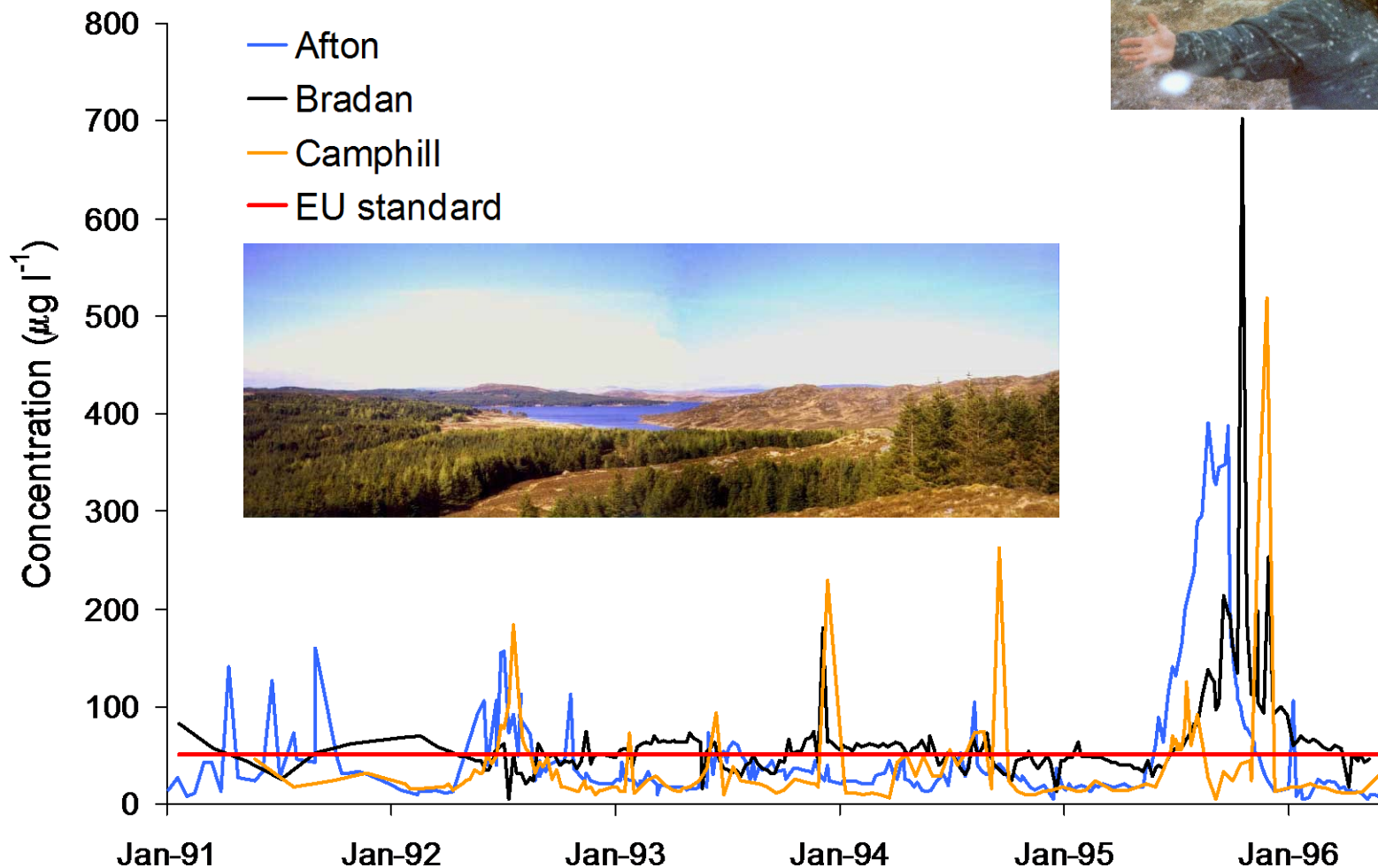


(Image: A. Hardie)

Example of using soil water measurements to address water resource management issues

Manganese concentrations in drinking water reservoirs, SW Scotland

Acknowledgment:
Alasdair Hardie



Soil moisture content and matric potential measurements in different soil types and land uses

Moorland

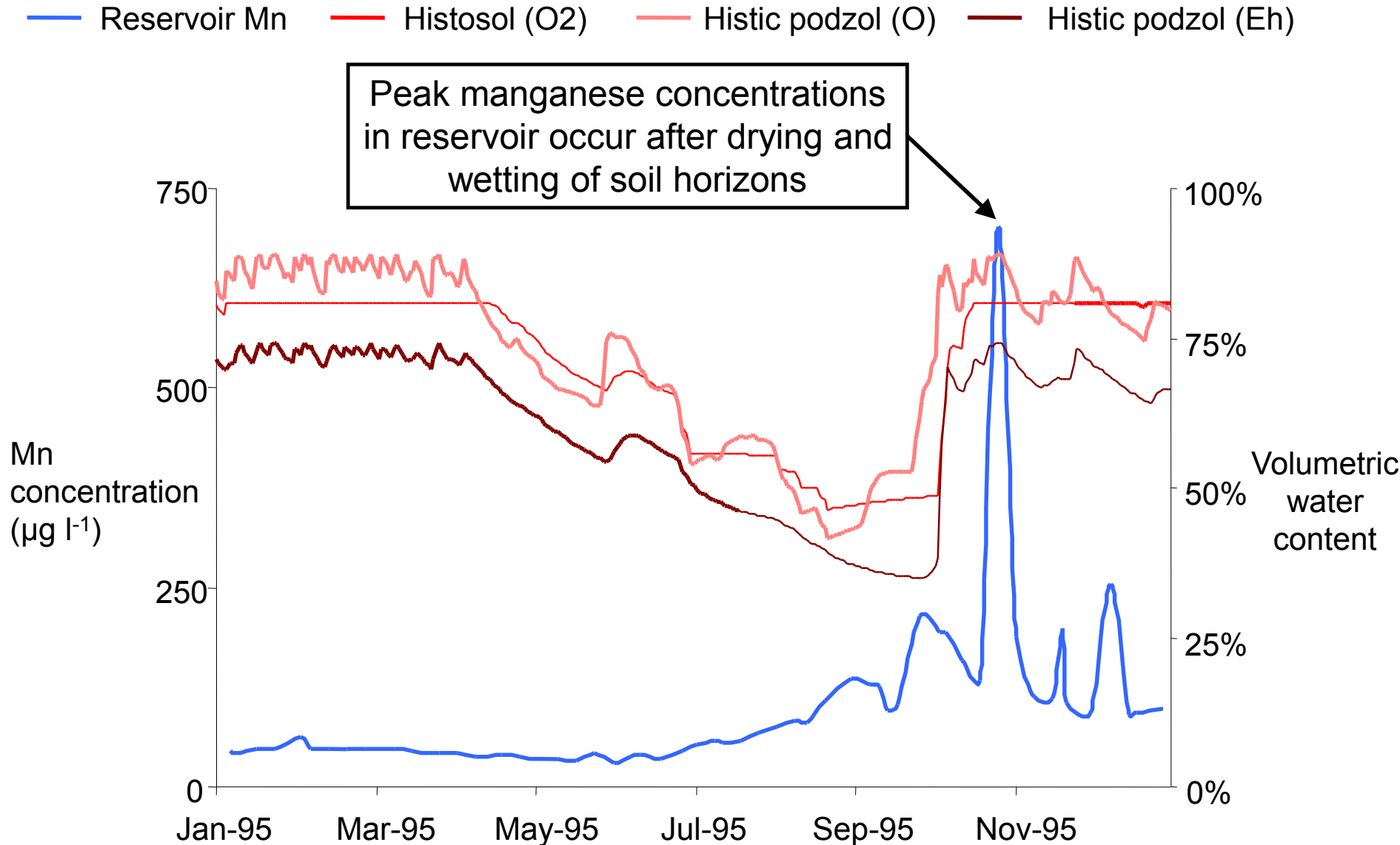


Forest



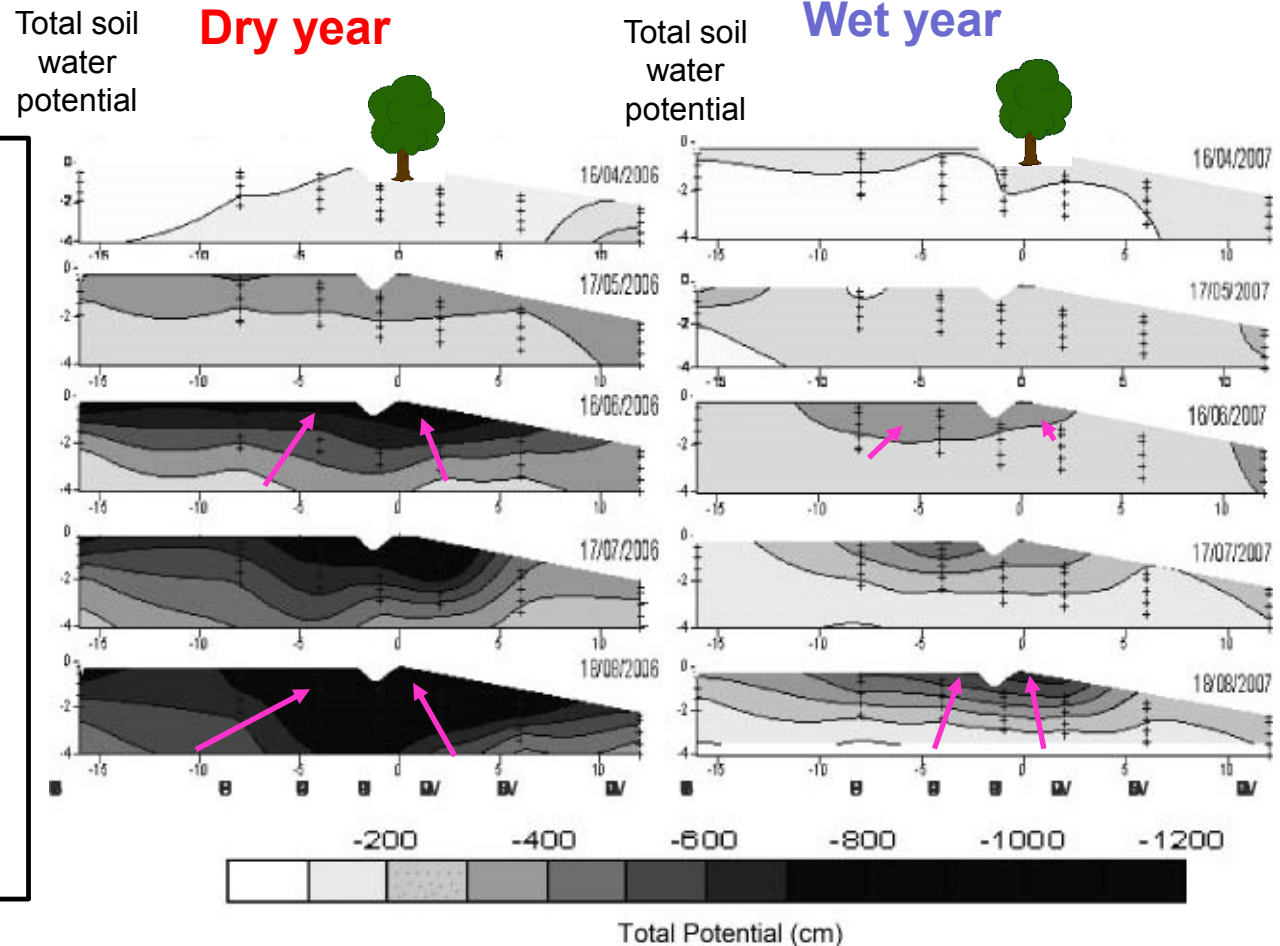
Data used to calibrate model of soil water regime for catchment soil horizons

Modelled soil moisture regime and reservoir Mn in 1995



Soil water movement

- Soil water always trying to achieve equilibrium, i.e. uniform potential energy
- => soil water moves from areas of high total potentials (**wet soil**) to areas of low total potentials (**dry soil**)



Total soil water potential measurements show upwards movement of water to hedgerow, with effect most marked in dry year => impacts of land use on flood risk and groundwater recharge