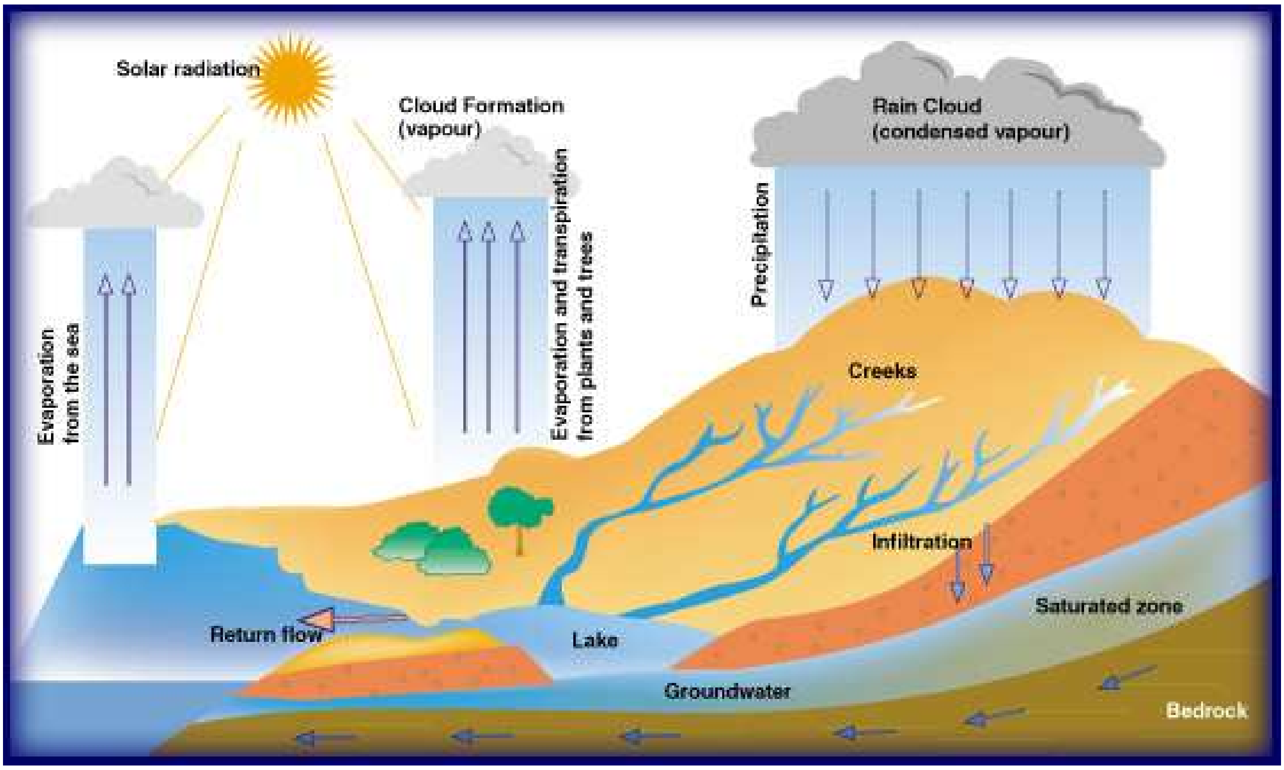
Water in the Farm System

Author– Joël Dunn, Catchment Officer

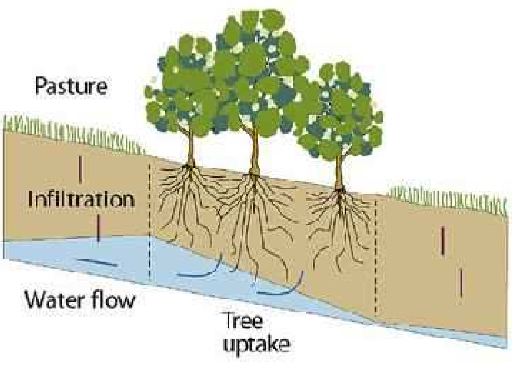
Water is a key natural resource that is a key component of all living things and essential for all life. Availability of reliable, good quality water is often the limiting factor for agricultural production. While rainfall cannot be controlled at the farm scale, the efficiency with which available water is used for production can be profoundly influenced by management practices.

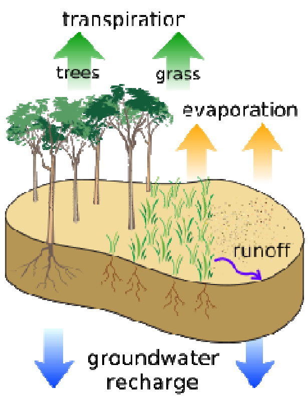
Water is a finite resource which cycles from the atmosphere to the earth and back to the atmosphere. As water cycles through the landscape and atmosphere, its movement is influenced by a complex of interacting components of the ecosystem.



Water provided to the landscape by rain, works its way downhill through the landscape to creeks and rivers and ultimately to the sea. It is returned to the atmosphere by evaporation, and by transpiration, which is the release of water to the atmosphere by plants. Atmospheric water vapour condenses to form clouds, and in turn, rain.

Trees and other plants pump water up from the soil through their roots, and release water to the atmosphere through transpiration from their leaves. Deep rooted plants increase water penetration and intercept water moving laterally through the soil profile, increasing local cycling of water and soluble nutrients while reducing water logging. Where there is more deep rooted vegetation present, there is more return of water to the atmosphere by transpiration over a longer period, and enhanced cloud formation.





Water quality and sustainable agriculture

The primary capital resource for farming is fertile soil, so the ideal situation for farmers is the creation of soil and the elimination of soil and nutrient loss. This is also the ideal situation for water quality, as lost soil and lost soil nutrients make a significant contribution to water quality problems when they end up in waterways. Healthy, productive soil makes the best use of rainfall, taking in and holding more water, reducing the impact of drought and flood conditions and producing runoff of lower volume and cleaner quality.

Clear runoff from the farm means the farm's resources are being conserved. If overland flow is cleaner after flowing through a farm, it is an indication of that farm gaining soil and nutrients.

Sediment plume from an Australian river– this amount of sediment runoff represents massive soil losses as well as damaging aquatic ecosystems [Source: CSIRO]

Keys to stopping soil and nutrient loss from water action include:

- Maintaining 100% groundcover with grazing management and fertility management
- Strategic use of deep rooted perennial plants– eg high perennial component of pastures, planned tree planting on steep slopes and in contour belts for shade, windbreaks, timber, food and biodiversity
- Use of mineral and biological fertilisers, and fertilisers that are stabilised with carbon content
- Inform fertiliser inputs with soil tests, restrict fertiliser application rate to soil's assimilation capacity.
- Contrary to 'conventional' understanding, fertilisers do not need to applied before a rain event. Rain can wash significant amounts of recently applied nutrients away from the target site. However, even in dry times, applied nutrients will be taken into the soil within three weeks. When rain comes, nutrients are there waiting to be accessed by plants.

Slowing the flow – holding water in the landscape

Unfortunately, understanding of the flow of water through a watershed ('catchment') is widely influenced by an 'engineering' perspective– treating the catchment as a 'drain' which simply channels water away. Past land clearing practices and agricultural practices including set stocked grazing have had a tendency to cause the landscape to become less 'porous', with accelerated flow of increased volumes of runoff. This kind of change in the landscape results in higher flood peaks that are reached more rapidly, less local water cycling and local cloud formation, and more rapid onset of effective 'drought' conditions when there are periods of low rainfall.

Australian innovations in integrated land planning, including Keyline Design, Permaculture and Natural Sequence Farming, focus heavily on the principles of slowing water flow and holding water (and its associated energy) high in the landscape. These systems advocate storing water primarily in the soil in the wider landscape, and relying less on large dams low in the landscape, which require more energy to pump water back up to higher areas on the farm, and which are now regulated by 'harvestable right' legislation.

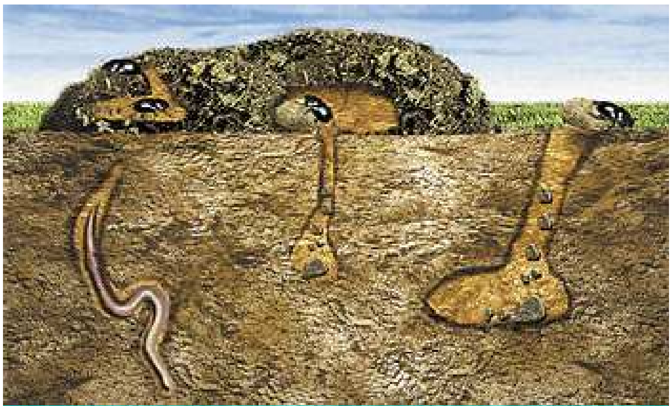
Keyline uses contour tree belts, water harvesting contour swales, and networks of small dams. Water infiltration into compacted landscapes is facilitated by cultivation with a custom chisel plow (Yeomans plough) which aerates the soil without turning it over. Ploughing is on contour, or slightly off contour to divert water flow away from gullies and towards ridges, slowing flow and increasing infiltration, soil aeration and biological activity to create topsoil rapidly. Permaculture built on Keyline planning to accommodate maximum diversity of production to mimic 'natural' ecosystems, often incorporating aquaculture as well as forestry to farm food production systems.

Natural sequence farming also works heavily on water management, slowing and spreading water flow with the use of 'leaky weirs' in gullies and creeks, and encouraging water to flow laterally across the landscape in braided diversion channels buffered with vegetation, again slowing flow, hydrating the soil, preventing erosion and reducing the impact of both flood and drought.

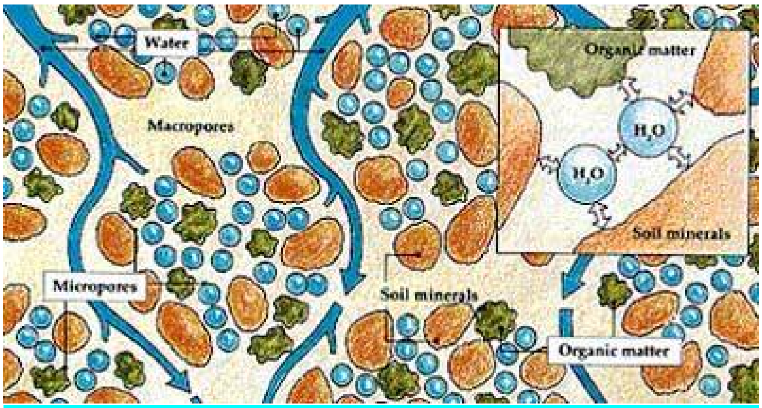
Soil structure, soil biology and water

To capture and hold water, soil needs a system of pores which allow water to move between and within soil aggregates. Organic matter in soil can hold up to seven times its own weight in water, so soils with high carbon and organic matter content hold more water for longer, allowing better plant growth and moderating drought and flood conditions. Soil biology plays an important role in soil structure, and maintaining healthy soil biology produces a porous, friable soil that makes better use of the water that falls on it, is less likely to erode, and is more resilient to drought.

Visible soil life (macrofauna)
Soil organisms visible to the native eye such as earthworms, dung beetles and other invertebrates leave tunnels in the soil which allow enhanced infiltration, as well as adding organic matter to the soil, which increases water holding capacity.

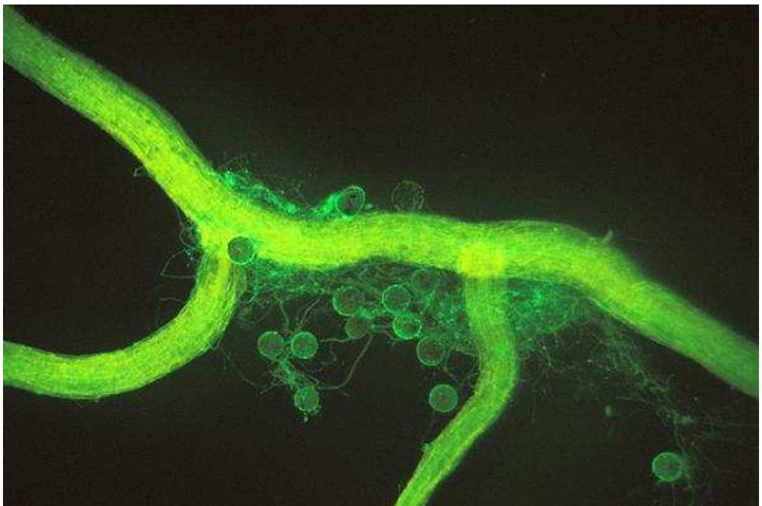


Dung beetles and earthworms aerate soil, improving water infiltration and water use efficiency



Soil structure and water movement (FAO)

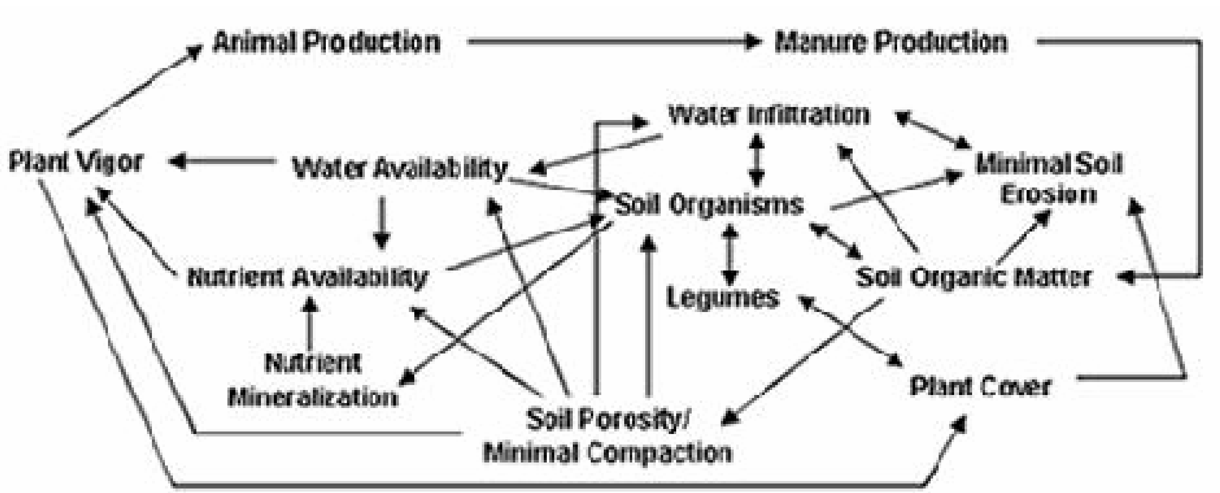
Microscopic soil life (microfauna)
Microbes are also very important for healthy soil structure. In particular, arbuscular mycorrhizal fungi that colonise plant roots produce a sticky glycoprotein called glomalin, which plays a key role in gluing soil aggregates together, improving porosity and resilience of soil.



Glomalin produced by fungal hyphae, stained and magnified

General measures to support soil biology

- Slow water flow in landscape
- Avoid turning the soil if at all possible
- Maintain 100% groundcover
- Use grazing management to give pastures adequate rest periods
- Be aware of potential impacts of pesticides and veterinary chemicals
- Feed the soil with manure based fertilisers and microbial ‘foods’.
- If inorganic fertilisers are used, add humates to stabilise nutrients and support soil life
- Mulching boosts organic matter

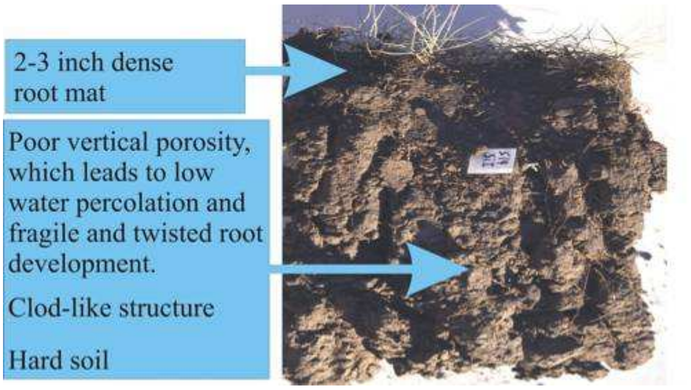


Water infiltration and water availability as part of the interconnected web of sustainable agricultural production

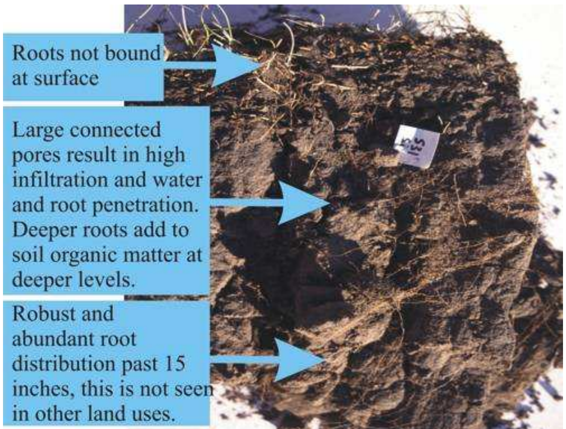
Grazing management and water use efficiency

The amount of water available for plant growth and agricultural production in general depends not only on rainfall, but just as importantly on the features of the landscape which receives the rainfall. Rain water needs to both infiltrate into the soil and be retained by the soil to be available for use by plants. Infiltration rate and water holding capacity can vary significantly in response to land management, and good soil can absorb and store much more water than poor soil. Where soil is compacted and lacks pores for water infiltration, much of the rain that falls on it is lost to runoff. In turn, high velocity runoff erodes soil away. Compacted soils in low lying areas are prone to water logging as water is unable to drain away.

Australian and overseas studies have demonstrated significant effects on water infiltration and water use efficiency in response to grazing management. A well managed planned grazing strategy will result in 100% groundcover, high soil porosity, high infiltration rate and minimal runoff. In contrast, intensive set stocking reduces groundcover, increases soil compaction, decreases infiltration and increases runoff and erosion.



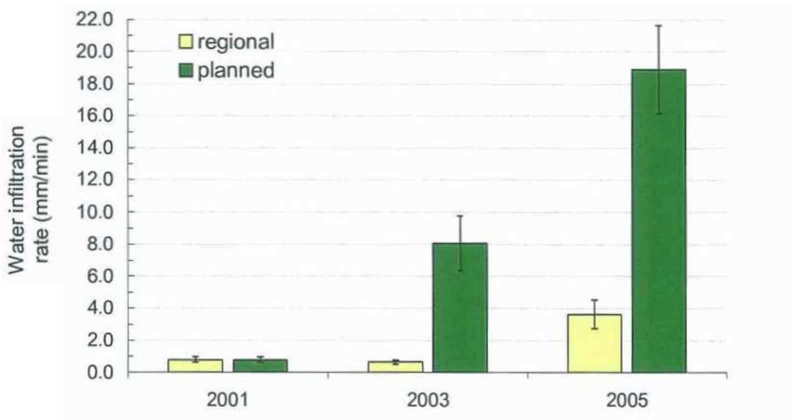
Soil sample from continuously grazed pasture



Soil sample from rotationally grazed pasture

(Images sourced from North Dakota State University Agricultural Experiment Station)

Grazing management studies in the Northern Tablelands showed greater than twofold differences in water use efficiency on adjacent properties in response to grazing management. This means that properties with good grazing planning were producing more than double the pasture produced on adjacent set stocked properties receiving the same rainfall, essentially doubling sustainable carrying capacity. The key to this kind of grazing management is to allow pasture sufficient recovery time after being grazed.



Water infiltration rates after five years of planned grazing, compared to regional averages on set stocked land. (Judi Earl 2008)

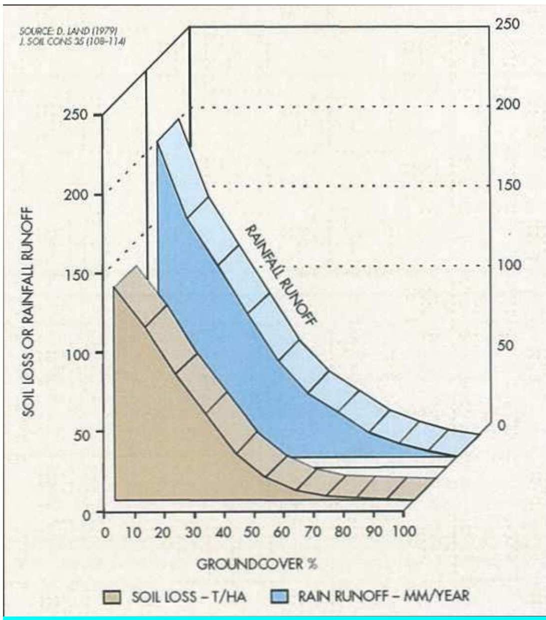
Longer recovery time means more root biomass and better water infiltration (Christine Jones 2006)

“The biomass of the roots and the tops of grasses are roughly equal, forming a mirror image… Deep, fibrous root systems provide a multiplicity of benefits including soil aeration, erosion control, enhanced nutrient cycling, soil building, increased water holding capacity and reduced groundwater recharge.” (Christine Jones 2006) In pastures grazed for extended periods, desirable pasture species are selectively grazed and kept short. This leads not only to a deterioration in pasture composition as unpalatable species gain a competitive advantage, but also to loss of groundcover, soil compaction, and loss of water and soil to runoff.

Groundcover and infiltration

Water runoff increases exponentially as groundcover decreases below about 75%. The target for soil health and soil retention and building, especially in high rainfall coastal areas, is 100% groundcover, at all times.

Full groundcover significantly increases water infiltration and water use efficiency. ‘Canopy’ groundcover is herbage above 5cm high, while ‘contact’ groundcover including prostate stems and leaves, leaf litter and basal root areas of plants, is herbage matter in direct contact with the soil. Both canopy and contact groundcover reduces the mechanical effect of rain impact loosening soil particles and the suspension of sediment into runoff water. Contact groundcover is very important in slowing runoff and increasing the deposition of nutrient rich sediment back to the soil.



Groundcover and runoff loss (NSW DPI)

Monitoring groundcover with a 50cm quadrat is a useful tool to improve groundcover management. The quadrat makes it easy to estimate groundcover in that defined area: stand directly over the quadrat and estimate the amount of ground covered by plants, litter and dung. For each paddock, record groundcover at about 20-30 random locations and calculate the average. Any area falling below 75% groundcover is in urgent need of recovery time.

At 20% groundcover
Run-off water loss = 160mm per year
Soil loss = 8.5mm per year
Poor plant production and sustainability
Low green leaf and plant vigour
Low water infiltration
Plants exposed to temperature extremes
Poor soil structure and surface sealing of soil

At 40% groundcover
Still much too low
Run-off water loss = 90mm per year
Soil loss = 4mm per year
Poor pasture and soil health

At 70% groundcover
Run-off water loss = 10mm per year
Soil loss = 0.3mm per year
Good plant production and sustainability
High green leaf and plant vigour
High water infiltration
Plant bases protected from temperature extremes
High organic matter content
Good soil structure and soil surface

At 90% groundcover
Reduced run-off water and soil loss
Groundcover should target 100% to retain topsoil, nutrients and to promote stable pasture conditions
Weed colonisation will be reduced when bare ground is removed

Source of groundcover images: NSW DPI