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MANAGING CLIMATE CONSTRAINTS

The Central Victorian climate poses some significant constraints to building and maintaining soil health.

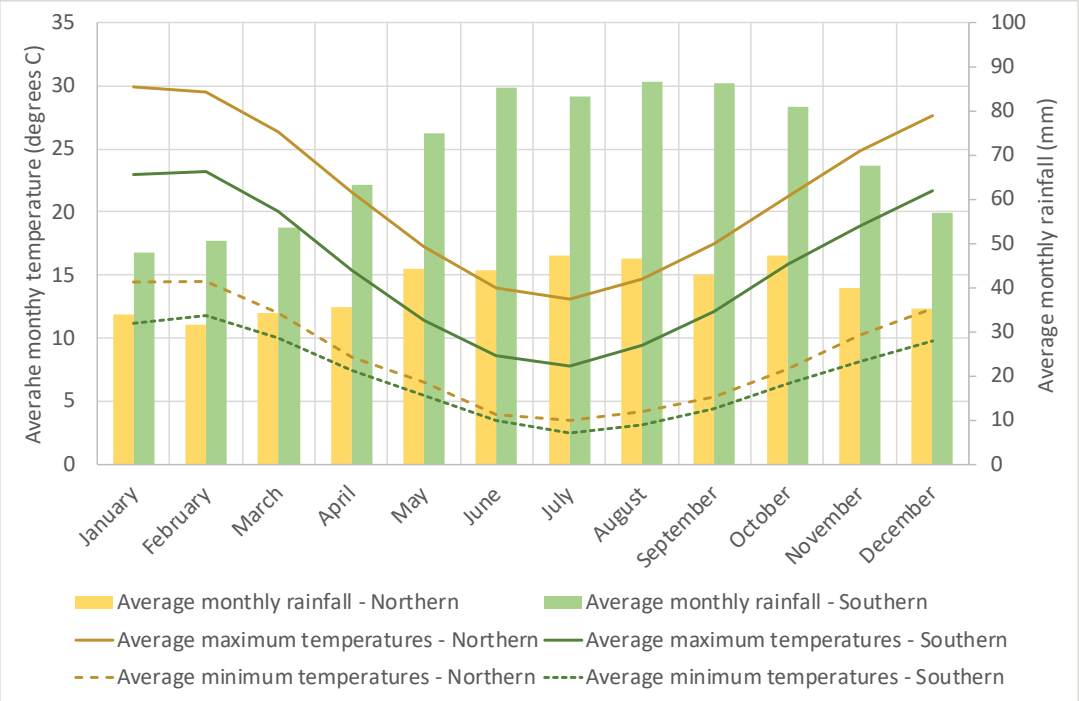
Management practices that are effective in higher rainfall and/or more temperate climates may not be as effective in drier and hotter areas.

The Healthy Soils Initiative covers an area with diverse climatic conditions. The southern area (from Kyneton to Clunes) has higher average annual rainfall (>650-750mm) and milder summer conditions, but cold winter months that can stunt plant and root growth. To the north (Elmore to Inglewood) winters are less severe, but annual average rainfall is less (~450-500 mm per year) and summers can be very dry with periods of extreme heat and drought that make it hard to maintain living groundcover on unirrigated land.

In the north, lower annual rainfall and typically dry and hot summers limit the ability to maintain living plant matter over summer. In addition, cropping farmers typically want to conserve soil moisture over summer by controlling weeds and are unlikely to benefit from cover crops over summer if these deplete soil moisture. During and immediately periods of extended drought conditions soil health and levels of organic matter are likely to go backwards, and effort may be needed to repair damage.

In the south, rainfall is typically higher and more reliable. Although summers can be dry and drought periods occur, pasture areas can usually

Figure 5.1: Average monthly rainfall in the north and south of the project area.



be managed to retain soil cover and remain green or dormant cover over most summers provided soils allow deeper root growth and areas are not overgrazed.

Central Victoria also experiences periodic strong El Nino and Indian Ocean Dipole affected weather patterns typically resulting in mild or severe drought conditions every few years. Dry soils bare of living plants and roots can severely set back efforts to build soil health because it depletes soil organic matter and damages the soil ecosystems that cycle nutrients, improve soil structure, and help hold organic matter in the soil.

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Under pasture systems, soil and grazing management and promotion of drought tolerant perennial species can improve water infiltration and achieve deeper root growth and help to carry living and dormant (alive but not growing) grasses and other species over most summers. Allowing areas to 'hay off' without heavy grazing by livestock or wildlife can also provide protective soil cover. During periods of extended drought, even this can be difficult.

Under cropping systems, the challenge of maintaining protective cover and using living or dormant drought- tolerant species to protect and feed soils is harder. In many instances. Farmers want to conserve limited soil moisture for the following crop, so are reluctant to carry growing plants over summer. In such instances, retaining as much crop residue straw as possible can help to protect soils. Even this can be a challenge under crops such as canola and peas that leave sparce residue.

During favourably spring and 'wet' summer and 'early autumn' conditions, biomass inputs to soils can be boosted and cover crop and green manure crops can be considered. Under pasture systems, work can be done to promote deeper root growth through the selection of plant species, grazing management and addressing sub-soil constraints. Under cropping systems, summer pastures, cover crops and green manures can usually be carried over milder summers if soils are deep and managed to retain rainfall.

The main objectives of making soils and plants less susceptible to dry periods are to: protect surface soils from 'baking' heat, make soils and plant roots deeper, and increase the amount of rainfall that infiltrates and is available to roots.

Key management options are:

1. **Improve soil water infiltration by improving soil structure/porosity.** This allows better water infiltration and deeper root growth. Soil porosity can be improved by managing livestock and vehicle traffic to reduce compaction, increasing organic matter in the soil, and on heavy sodic or magnesic clays the addition of calcium as gypsum, lime (on acidic soils) or other amendments. Strategic tillage may also be used to break up heavily compacted soils and integrate organic matter and soil amendments such as gypsum, lime and compost.
2. **Maintain a surface ground cover of living, dormant or dead 'mulch' plants** that will slow water flow and improve surface porosity
3. **Where tillage is used, working along contours** (i.e. across slopes rathe than up and down them) will also slow water flow and increase water infiltration.
4. **In pastures, promote a diversity of perennial and annual summer and winter active plants**, including deeper rooted grasses, nitrogen fixing legumes and other herbs with deep roots and good feed quality. Consideration needs to be given to constraints to deeper root growth such as soil compaction, hostile pH, and lack of nutrients. Some plants, including many legumes and the nitrogen fixing bacteria they host, are sensitive to overly acidic pH, aluminium toxicity and poor availability of trace nutrients. If these constraints are present on your farm, you may choose to sow more tolerant plants and apply appropriate levels of lime and fertiliser so deep rooted and nitrogen fixing plants can become better established.
5. **Avoiding over-grazing by livestock and wildlife** – particularly in summer and during winter months where plant growth can be slow. This main mean resting areas that have slower growth, reducing stocking numbers and culling or fencing to reduce wildlife grazing pressure.
6. **In cropping systems, consider longer rotations** that include a mix of legumes, cereals, oilseeds, fodder/hay crops and pasture or ley 'rest' phases. In areas with more reliable seasonal and summer rainfall, consideration can be given to under-sowing or strip-sowing crops with summer active plants that will not compete significantly with crops, but will provide living or dormant ground cover and fodder into summer months.
7. **When seasonal conditions and outlooks allow, use favourable seasons to increase the amount of biomass added to soils.** This includes 'locking up' paddocks for periods to allow deeper roots to develop and cutting hay and/or managing grazing so that these roots remain alive and plants are grazed when they have high feed quality.
8. **In drier areas and seasons, termination of summer growth may be needed** to preserve soil moisture for the following crop and add biomass to the soil. If this is done it is important to maintain a surface groundcover of dead organic matter over summer to protect soil from baking heat and erosion.

Managing Soil Health during and after drought

Central Victoria is no stranger to drought. Summers are often dry and periodic El Nino can result in low rainfall over the autumn to early summer growing period, sometimes for several years in a row. Dry summers and extended period of drought not only affects agricultural productivity but also has significant impacts on soil health. Observed and predicted climate trends for northern and central Victoria are for reduced and less reliable average growing season rainfall, more frequent extreme summer heat events and more frequent

intense summer rainfall events. This means soil management strategies that promote deeper root access to soil moisture and conserve summer rainfall will become more important to maintaining yields.

Drought has direct and indirect impacts on soil health, including:

1. **Soil Moisture Depletion.** Extended periods of dry weather lead to a decrease in soil moisture levels. This dehydration affects levels of organic matter, soil biology and soil structure, making soils more susceptible to erosion and compaction.
2. **Risk of bare and unprotected soil over dry periods.** This exposes soil erosion from wind and summer storms, as well as baking heat and drying that kills soil biology and depletes soil organic matter.
3. **Disruption of soil ecosystems.** Extended drought can result in the death of more complex fungi and bacteria that hold and cycle carbon and nutrients, earthworms and other beneficial soil-building organisms. When the drought breaks there can be population explosions of more opportunistic bacteria that rapidly consume organic matter and draw down nutrients for a while. It can take several months or more for more complex and beneficial soil ecosystems to become reestablished and consecutive dry years can impact soil health for years.
4. **Loss of Soil Organic Matter:** Drought accelerates the decomposition of soil organic matter, leading to a decline in soil carbon levels. Reduced organic matter content diminishes soil fertility and water-holding capacity.
5. **Nutrient Imbalance:** Drought disrupts nutrient cycling in the soil, affecting the availability of essential nutrients for plant growth when the drought breaks. Nutrient imbalances may occur, leading to deficiencies or toxicities in plants, e.g. acidic soils with high manganese levels can experience manganese toxicity after hot and dry periods.

Effective soil management during drought is essential for mitigating the negative impacts and maintaining soil productivity. Some strategies for managing soil health to improve drought resilience include:

1. **Make soils deeper:** Address sub-soil constraints such as compaction, hostile pH and low nutrition.
2. **Conservation Tillage:** Adopt conservation tillage practices such as minimum tillage or no-till to reduce soil disturbance and minimise moisture loss. Conservation tillage helps maintain soil structure and organic matter content, enhancing drought resilience.
3. **Mulching:** Retain plant residues or apply organic mulches such as straw, hay, or compost to conserve soil moisture and regulate soil temperature. Mulching also prevents soil erosion and suppresses weed growth, promoting soil health during drought.
4. **Cover Cropping:** Plant cover crops during fallow periods to protect the soil surface, improve soil structure, and enhance soil fertility. Cover crops contribute organic matter to the soil and reduce erosion risk during drought.
5. **Soil Amendments:** Apply soil amendments such as organic matter, compost, or gypsum to improve soil structure and nutrient availability. Soil amendments enhance soil water-holding capacity and promote microbial activity, aiding in drought recovery.
6. **Crop and pasture selection:** Choose drought-tolerant plant varieties and rotations suited to local soil and climatic conditions.

Rehabilitating soil health after drought requires targeted interventions to restore soil fertility and resilience. Some additional strategies for managing soil health after drought include:

1. **Soil testing:** Conduct soil tests to assess nutrient levels, pH, and organic matter content post-drought. Soil testing provides valuable insights for developing tailored nutrient management plans and restoring soil fertility.
2. **Soil fertility and pH management:** Apply balanced fertilisers and soil conditioners based on soil test recommendations to replenish nutrient reserves and correct imbalances.
3. **Restore soil organic matter.** Implement practices such as greater retention and integration into the soil of crop and pasture biomass and compost application to replenish soil organic matter lost during drought.

Key messages

1. The central Victorian climate can be a significant constraint to the Healthy Plant ⇆ Healthy Soil cycle.
2. Management practices developed and promoted in milder and higher rainfall areas on better native soils may not be as applicable in parts of central Victoria, so climate as well as soil constraints need to be considered and managed.
3. Extended dry periods, drought and summer heat conditions can make it hard to maintain living and dormant plants and can result in rapid loss of soil organic matter.
4. Overgrazing by livestock and wildlife over summer periods can reduce the potential for dormant plants to survive and respond to summer and autumn rains.
5. Bare soil is also prone to baking heat and erosion.
6. Cold winter conditions slow plant growth and can result in overgrazing by livestock and wildlife and reduce root growth and the potential for plants to grow vigorously in spring. Shallow roots also make plants more susceptible to dry conditions and reduce how much biomass plants can add down the soil profile.
7. Climate constraints can be managed by:
   a. Improving the water infiltration. This can be achieved by reducing compaction, maintaining a cover of living, dormant and dead plant matter over the soil surface, and creating surfaces and contours that slow the flow of water across land.
   b. Improving the soil water-holding and plant-availability characteristics of soil. This can be done by increasing the organic matter content of soil.
   c. Managing grazing by livestock and wildlife to maintain at least 5cm high ground cover and allow plants to grow deeper roots.
   d. In cropping systems in lower rainfall areas or forecast drier years, managing summer weeds so that stored soil moisture from any summer and pre-sowing rain is conserved for the following years' crop. This may involve chemical or physical termination that leaves a 'mulching' layer of dead organic matter lying on the surface.
8. Soils need to be protected in bad seasons and may need to be repaired after extreme disruptions to soil health.
9. Good seasons can be used to add more biomass to soil.