Assisting to manage soils and landscapes post-fire – Fact sheet from Soil Science Australia

Impacts of fire on soil

Fire can have severe, long lasting and even irreversible effects on soil. These effects will be different depending on the intensity and severity of the fire, the soil type and condition, weather, topography and especially aspect. The top (<10 cm) soil layer can be severely affected but the affected soil depth will vary according to fire and soil properties. Major effects of bushfires on soil include:

- *Increased erosion risk* – the destruction of vegetation cover in bushfires greatly increases the amount and impact of rainfall reaching the soil, and exposure to wind. This can result in severe soil and ash erosion post-fire, erosion rates can be orders of magnitude above normal pre-fire levels. The erosion greatly increases water quality and ecological risks to downstream water bodies. Erosion risks will be greatest in areas with steep north facing slopes and where high rainfall occurs, and will vary with soil type. Wind erosion can transport ash a long distance and create serious air pollution issues.
- *Organic carbon and nutrient loss* – some soil organic carbon will be combusted (oxidised to carbon dioxide) and lost from the soil, particularly in the high temperatures (>450°C) present in intense bushfires. The loss of organic carbon increases with fire intensity and duration. Some soil nutrients (in particular nitrogen but also phosphorus and sulfur) can also be combusted and lost from the soil during bushfires. Transformation of nutrients to more soluble forms can occur, resulting in increased nutrient leaching following rainfall. However, different vegetation types and soils will have variable nutrient losses post-fire. Loss of organic carbon and nutrients following fires generally results in a decline in the fertility and productive capacity of the soil, although some short-term increases in the availability of some nutrients in the ash produced is possible.
- *Water repellence* – fire-induced soil water repellence can occur when heating of the surface and near-surface soil causes the vaporisation of organic compounds, which move downwards through the soil profile in response to temperature gradients, and subsequently condense and form a hydrophobic layer or coating around soil particles. This reduces water infiltration, increasing runoff and erosion risks and also reducing water availability to plants/crops. Water repellency effects have been shown to be not universal and can be variable in different fires and soil types. Simple field "water droplet" tests can be used (see information sources below) to assess this.
- *Irreversible alterations to soil minerals and structure* – fire may cause severe mineral alterations to the soil including the permanent conversion of some minerals into new minerals under a range of temperature conditions. A coarse fraction comprising hard, cemented (fused) ceramic-like porous fragments is formed within ashy material from clayey soils with high organic matter (e.g. burnt peaty clays). This material is classified as "fusic material" in the Australian Soil Classification. Extremely high temperature fires (>800°C) have been shown to melt very saline acid sulfate soils to form masses of sintered and vitrified / glass-rich groundmass. The subsequent effects of these changes are less studied but trace element availability and soil structure is affected.
- *Soil sterilisation* – the high temperature in fires may kill microbes in the soil that perform highly beneficial functions relating to nutrient cycling, affecting nutrient availability to plants. However, heat does not penetrate deep into the soil profile and soil microbes can readily recolonise the site on dust blown in on the wind.
- *pH changes* – the creation of ash in bushfires concentrates base cations such as calcium and magnesium, and can also create calcium carbonate. Often the pH of the top soil can increase, which could alter trace element availability and have some effects on the type of plant species that re-establish.

Potential soil management strategies post-fire

- *Erosion control structures* – erosion control structures can be built to trap sediment. This can involve natural strategies involving strategic placement of log barriers, hay bales or silt retention structures. High risk areas with steeper slopes or more erodible soils should be prioritised.
- *Minimise soil disturbance* – the soil is in a fragile state post-fire. Impacts of machinery on the post-fire landscape needs careful consideration when implementing active management strategies (e.g. to avoid damaging recovering vegetation or soil structure). Grazing should also be deferred where possible until the soil is stabilised.
- *Clay incorporation* – water repellency may be reduced by incorporating clay into the affected layer(s) where practical. There are also commercial products available to increase soil wettability.
- *Mulching* - 'Mulching' (e.g. with straw, branches or bark) is one measure that has been shown to be effective in limiting erosion in the immediate post-fire period. However the method can be expensive to apply on a large scale and have unintended and negative consequences if new plant species are introduced via seeds in the mulch mixture.
- *Re-establishing vegetation cover* – where natural vegetation recovery is not possible or limited, active revegetation strategies can be used to try and stabilise the soil surface. Seeding with grasses has been used to achieve rapid soil stabilisation but caution needs to be applied in introducing any species that may later out-compete native species. In an agricultural context, rapid re-establishment of cover or cereal crops is likely to be beneficial until full production systems can be restored.
- *Fertilisation* – if nutrients are lost from agricultural landscapes following bushfires then fertiliser application may be beneficial to assist in crop re-establishment. It is recommended that conventional agricultural soil testing is undertaken to assess whether this is required. Nitrogen loss has been found to be proportionally greater that phosphorus loss so nitrogen fertilisers may be most beneficial. Micro-nutrient balances may also be altered by fires but this is less understood. Use of slow release fertilisers is recommended to reduce losses during rainfall.
- *Water quality management* – the markedly increased erosion risks following bush fires may have severe impacts on water quality. The assessment and management of downstream water resources may need to be included in post-management strategies to prevent unacceptable risks of ash and sediment (e.g. on drinking water treatment plants or stock water supplies). Skimming floats and techniques can be used to removed floating materials, or filtration employed.

Determining the best timing to implement any management strategy is also important (e.g. wait until sufficient soil wetness is present to re-establish plant cover). Erosion control needs to be the initial focus.

It is well known that Australian soils have been impacted by fire for thousands of years. However, the current extreme heat waves, drought conditions and high accumulative fuel loads, especially in surface soils have resulted in soil burnings at higher temperatures. Higher temperatures and reduced rainfall in Australia due to climate changes increases the risk of bushfires and severe soil impacts. As a long term strategy Soil Science Australia supports increased action to reduce Australia's greenhouse gas emissions to support global climate change mitigation efforts.

Sources of further information:

- Review of impacts of fires on soils
- Victorian Resources on Fire and Soil Health
- Wind erosion guide
- NebGuide – Emergency wind erosion control
- Western Australia information on wind erosion control after fire
- Case study from NSW of fire impacts and management measures
- Mineral transformation in wetland/acid sulfate soils following fire
- Field water repellency test
- Landline video on recovery from Pinery bushfires in South Australia
- GRDC Fire Web Resources
- Hydromulch post fire application
- The importance of ploughing before rain