Impacts of fire on soil

Notes prepared by Neil McKenzie (CSIRO Land and Water, Canberra)

Email: neil.meckenzie@csiro.au

(These notes were sourced from a forthcoming book 'Australian soil: an illustrated guide')

The response of a landscape to fire is partly determined by its suite of soils. The forested landscapes of southeastern Australia have a great variety of soil types but they can grouped into five broad classes.

Organic soils of the alps

Features

- Range from well drained soils with abundant organic matter (alpine humus soils) to peats depending on topographic position
- Soils are dominated by large quantities of organic matter
- Strongly acid
- Sub-alpine and alpine environments with short growing seasons

Impact of fire

- Very prone to erosion when vegetative cover is lost
- The harsh environment, short growing season, and low levels of nutrients ensure recovery is very slow (decades)
- Peat bogs, if incised by erosion gullies, can degrade and contribute significant quantities of particulate and dissolved organic matter to waterways
- Loss of peat bogs will also reduce the water storage capacity of the landscape

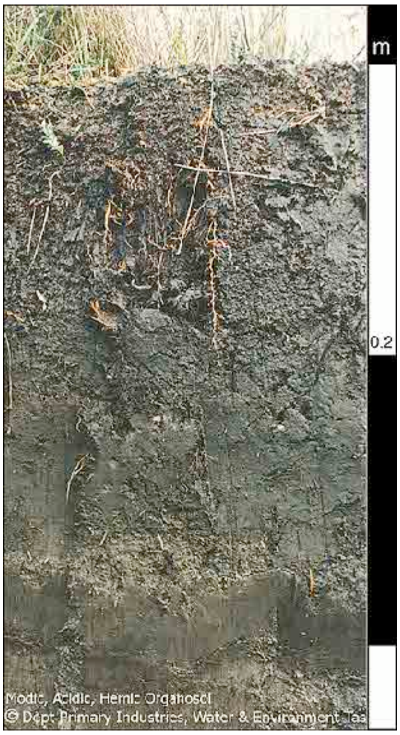

Figure 1. A peat soil in a subalpine landscape

Gradational earths

Features

- Gradual changes in clay content down the soil profile.
- No layers that restrict water movement or storage.
- Good surface infiltration and a capacity to store large amounts of water.
- Common in high rainfall areas (>1000 mm year)
- Often support wet sclerophyl forests (e.g. alpine and mountain ash)

Impact of fire

- Relatively resilient soils
- Possible increase in runoff and erosion due to loss of cover and water repellence
- Effect of water repellence is balanced by naturally high levels of porosity at the land surface (rainfall will runoff but most will enter the soil within a few metres and erosion will be minor)

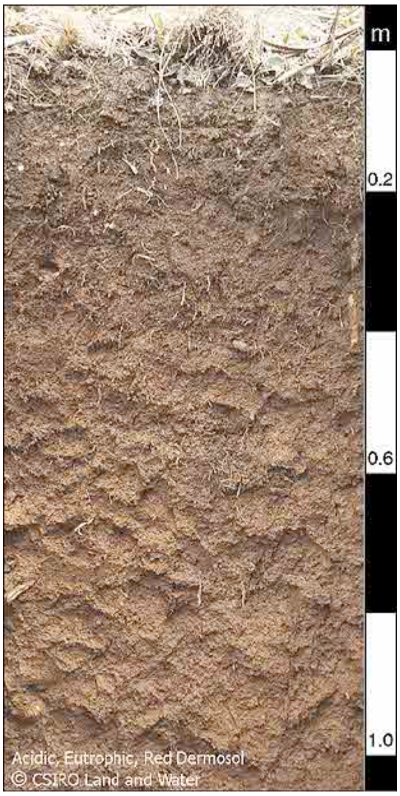

Figure 2: Gradational loam-textured soil

Texture-contrast soils

Features

- Abrupt increase in clay content down the soil profile
- Subsoil layers can restrict drainage and cause waterlogging
- Often erodible
- Common in areas with moderate rainfall (650-1000 mm year)
- Often support dry sclerophyll forests

Impact of fire

- Increased runoff and erosion
- Profiles on lower slopes and in gullies will be waterlogged after extended rainfall and this may lead to gully erosion
- Long term loss of nutrients due to erosion and burning may be significant

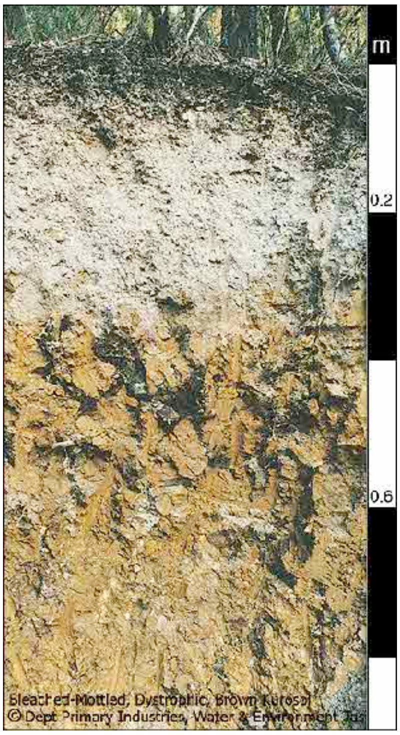

Figure 3. Texture-contrast soils are very common in south east Australia.

Gravelly soils

Features

- Abundant gravel throughout the profile
- Generally well drained
- Common on exposed and steep slopes

Impact of fire

- Potential loss of already very low levels of nutrients
- Possible erosion

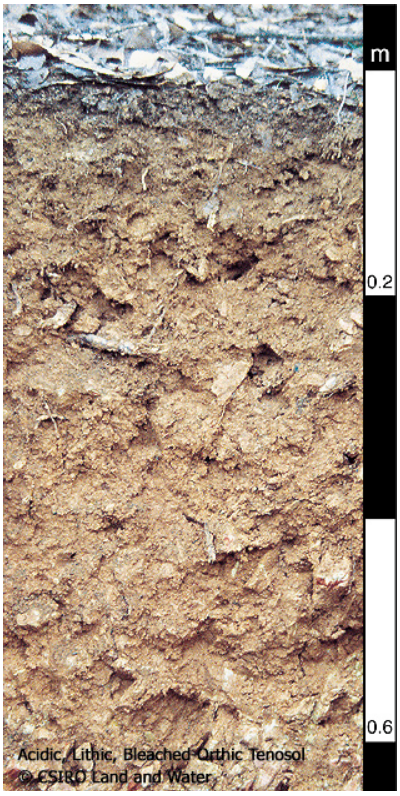

Figure 4. Shallow, gravely soils are common on exposed and steep slopes.

Sands

Features

- Low nutrient stores due to the sandy texture
- Generally well drained unless the soil overlies shallow rock
- Limited capacity to store water
- Common on sandstones (e.g. Sydney Basin) and coastal plains (e.g. Croajingalong NP)
- Usually associated with heathland species

Impact of fire

- Potential loss of already very low levels of nutrients
- Very strong water repellence but erosion is minor due to generally low slopes and sandy texture
- Vegetation is well-adapted to fire

Figure 5. Sandy soil.

Fire-induced changes to soil

Low-intensity fires are common in Australian forests and only heat the upper few centimeters of the soil profile to any great extent. More intense, long-lasting fires, such as those under piles of logs, can heat the soil to a greater depth and modify soil properties to approximately 0.5 m, but the temperatures reached depend on factors such as the initial water content and soil texture.

Soil temperatures associated with different types of fire are shown in Figure 6. Heating initially affects biological activity whereas intermediate temperatures from sustained heating are needed to effect chemical changes. Permanent physical alteration tends to occur only at very high temperatures. Some of the main soil changes caused by fire are summarised in Table 1.

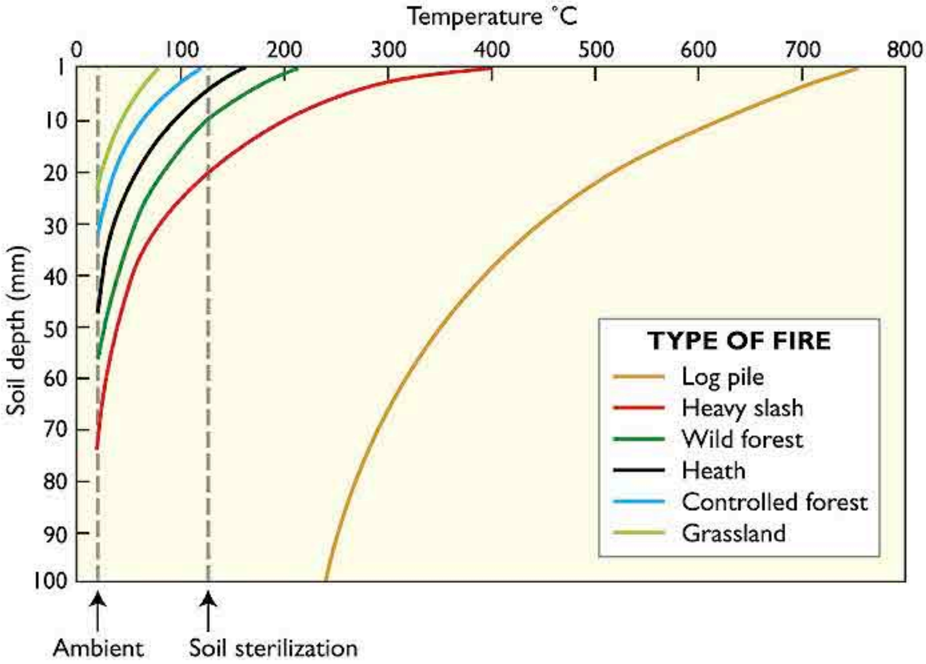

Figure 6. Temperatures in the soil profile for various kinds of fire.

Dominant type of change	Temperature (°C)	Change
	>1200	Loss of calcium as gas
Physical		
	950	Clay minerals converted to different phases
	600	Maximum loss of potassium and phosphorus
		Fine ash produced.
	540	Little residual nitrogen or carbon left
	420	Water lost from within clay minerals causing change in type
	400	Organic matter carbonized
Chemical		
	300	Maximum amino acid nitrogen released
		Loss of sulfur and phosphorus begins
		Organic matter charred
	200	Water repellence caused by distillation of volatiles
		Loss of nitrogen commences
	125	Soil sterilization
	110	Soil water lost
	100	Soil ammonium production starts
	70	High nitrate mineralisation
Biological		
	50	Mild sterilisation owing to water loss
	37	Maximum stimulation of soil microorganisms
	<25	Usual soil temperatures

Table 1: Changes in soil and plant material after heating (after Raison and Walker 1986).