

Recovery of Australia's soils following bushfires

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While attention to bushfire recovery often centres on above ground developments - rebuilt buildings and a return of green tree canopies - it's what happens below the surface that often determines how successful recovery actually is.

The 2019-20 Australian bushfire season was one of the most widespread and destructive in living memory. Starting in drier parts of Queensland as early as June 2019, the fires advanced south with the change of season.

Between September 2019 and January 2020, an estimated 7.38 million hectares were burned, including 5 million hectares of conservation land, 1.84 million hectares of state forests and plantations, and a further 0.53 million hectares of agricultural land.

The impact of the fires on the affected managed and natural ecosystems was extensive. In addition to ecosystems that rely on fire for regeneration such as eucalypt-dominated sclerophyllous forests, in NSW >50% of relict Gondwanan rainforests were impacted.

Based upon areas burned and known geographical distribution of fauna, over 1 billion animals are estimated to have perished in New South Wales and Victoria. This figure does not include platypuses, bats, frogs, insects or other invertebrates, nor does it take in to account losses in Western Australia, South Australia and Queensland.

What is less clear is the impact of the bushfires on the soils that support these ecosystems and agricultural productivity.

Impacts of fire on soil

Australia's soils are diverse and often ancient, having co-evolved over millions of years with the ecosystems that they support. Though altered by conversion to agriculture, soils underpinning agricultural production retain key properties stemming back to their formation and the native vegetation that once occupied them. Given their slow speed of generation, they are effectively a non-renewable resource and are prone to degradation - particularly following disturbance from fire.

Soil Science Australia has studied the direct and indirect impacts of



The orange ground colour shows where the soil carbon has been burnt out (the linear shapes where this occurred indicate where logs, etc, have completely burnt). Image: Suzanne Prober.

bushfire on soil. Typically, direct impacts of fire only affect surface (<10 cm) soils, and relate both to the impact of heat and the deposition of ash, which can alter pH and nutrient availability.

Farmers know the importance of the soil's microbial community to aid resilient production. However, microbes are just as central to the health of native flora. Fire can damage these microbial communities, as well as many nutrient and organic matter cycling functions.

Research undertaken at a site impacted by the 2013 Bookham fire in NSW showed differences in response of soil nutrient cycling and microbial community composition dependent upon land use. Although we were unable to recover much reliable data from the soil temperature sensors that were deployed on our field sites impacted by the fire, the very fact that some survived in the pasture whilst all were destroyed in neighbouring bushland that backs onto Burrinjuk Nature Reserve demonstrates the differences in fire intensity.

So there is significant nuance in how soils are impacted by fire.

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Factors include a fire's speed, direction, intensity and fuel load, and affect both the soil itself and the properties and subsequent behaviour of the ash and char left behind.

Increased hydrophobicity

Soil hydrophobicity - a tendency for soils to repel water on their surface - may also increase due to the transformation and movement of organic matter in the soil and litter. Increased hydrophobicity can lead to a reduction in water available to plants for their re-establishment or recovery. In turn, this can lengthen the time in which soils remain bare, exposing them to a greater chance of erosion.

Erosion

Erosion of soils following bushfire is possibly the greatest hazard to recovery, both to the impacted landscape, but also land, water and air resources further afield. In areas with steep gradients, both ash and topsoil now unprotected by vegetation may be eroded into watercourses, dramatically altering their chemistry and increasing turbidity. Following significant rainfall, deep gully erosion may also occur. In flatter areas exposed to high winds, such as many of the agricultural properties affected by the Kangaroo Island fires in South Australia, wind erosion can be a significant issue.

So, what can be done to assist soil recovery?

Options for recovery or mitigation in agricultural areas

Fires often burn quickly and with lower intensity over crop lands and pastures. Nonetheless, agricultural soils may often be more vulnerable to erosion following a fire because almost all aboveground organic material is lost in pasture and cropland, often including the litter layer built up under no-till cropping. As a result, very little protection remains for topsoil.

Management of newly burned soils in an agricultural setting is very much case dependent upon soil type, farming system, fire intensity, subsoil moisture availability and anticipated weather before the next planned land management activity. With prevention of erosion the primary goal, a number of options are available to land managers.

In sandy soils with a lower clay horizon within reach of a plough, clay spreading and delving i.e. deep tillage to bring up sufficient clay to reduce erosion whilst also potentially limiting hydrophobicity and improving infiltration may be an option. Care should be taken however if the subsoil is known to constrain production as such activities may create further problems down the track.

Whilst a high up-front cost, claying or the application of organic amendments to particularly vulnerable areas may not only reduce the immediate risk of erosion, but also offer longer-term benefits to production. Dependent upon subsoil moisture and timing, it may be beneficial to establish a cover crop, either single species or mixed, though care should be taken to ensure that such an approach wouldn't compromise the following cash crop.

Investigate first

Before undertaking any amelioration activity, it's important to fully investigate the scope of the damage. In sandier soils, even dead remnant roots may hold topsoil together better than cultivation. Withholding unnecessary traffic and grazing is also vital, and weeds may provide a beneficial role in holding soil in place.

Following fire, it is also important to undertake soil testing, which will provide insight into changes in properties such as pH and organic carbon that may require monitoring or addressing. Further, if the microbial community is sufficiently compromised by the heat of the fire and subsequent damage to the soil, it may be easier for disease to create a foothold.



Evidence of soil carbon burnout after a bushfire, in this case more than 2cm deep in the soil. Image: Suzanne Prober

Options for recovery or mitigation in areas of natural vegetation

In natural environments, recovery of soils is dependent on recovery of the vegetation. Many areas will rapidly recover as ground-layer species such as ferns, forbs and grasses start to re-sprout or germinate. Key to assisting ecological recovery is identifying areas where such natural recovery may be slow or impeded (e.g. vegetation types such as rainforests that are not well adapted to fire), and slopes that can create erosion concerns. These areas could benefit from attention to managing erosion and soil biophysical conditions.

Where intervention is considered desirable, actions could include dense replanting using seed and seedlings (in an appropriate season), or use of log erosion barriers, mulches or fibre webbing material.

Where run-off of sediments into streams is of concern, there is also good evidence to show that restoring grassy or herbaceous buffers of 20-40 m wide is effective. A more recently emerging experimental intervention is soil inoculation to promote an artificial biocrust. For example, inoculation with cyanobacteria has been shown to reduce hydrophobicity especially in finer textured soils that are richer in organic carbon and nitrogen.

Trade-offs and impacts

Finally, it is always important to be wary of potential trade-offs between the need to restore soils and other elements of the ecosystem. For example, introduction of foreign soil microbes could lead to undesirable outcomes e.g. phytophthora infestation, and promoting ground-cover may conflict with the need to control undesirable invasive species. Such trade-offs would need to be individually assessed by land managers.

Beyond the fire ground, impacts on downstream ecosystems and assets should be monitored, particularly drinking water storage, and impacts on these considered when remediation on the fire ground is planned.

Ongoing management required

Australia and the world looked on in horror to the damage caused by the bushfires, wondering how long areas would take to recover - and in some instances whether recovery was possible at all.

Land managers should be aware of the risks of doing nothing, but also of the potential for inappropriate intervention (e.g. ploughing a paddock that has retained root matter) to exacerbate land degradation.

The good news is that much of the area burnt out is adapted to naturally recover, even if it will take many years to regain all of its vegetation and wildlife.

With care and attention, our agricultural and ecological soils can recover from fire.