Bushfires and storms threaten water supply and much more

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Fatalities resulting from the post-fire debris flow was 10 times greater than those resulting directly from the wildfire in California 2018. Credit: Jason Kean, US Geological Society

Most of the drinking water for our cities and towns comes from densely forested catchments in nearby mountains. These catchments act like large, and very cost effective water treatment plants, slowly filtering rainfall through the soil before releasing clean water back to rivers and reservoirs.

In fact, this natural water filtration system is so effective that very little additional treatment is required, which minimizes the need for large and expensive water treatment plants.

However, while this fortunate situation provides a very low-cost source of water, it also creates a vulnerability in our water supply system.

More often than not, our Australian catchments are vegetated with highly flammable Eucalyptus forests. A bushfire in a catchment can have major impacts on water supply; heating from the fire causes the soil to become hydrophobic (water-fearing), while the loss of vegetation exposes the soils, greatly accelerating soil erosion.

The catchment no longer acts as a water treatment plant, and serious and sustained water contamination from soil and ash can follow, resulting in undrinkable water. Reservoirs can be unusable for months. These erosion events can be extreme in magnitude, and the results can be devastating, not just for our water supply.

Soil erosion from steep forested mountains (which are common in our south east Australian catchments) is typically high episodic; long periods with little erosion, punctuated by infrequent, but very high magnitude erosion events such as landslides and debris flows.

Fire creates the right conditions for these high-magnitude events to occur. For example, a thunderstorm following the 2018 Thomas Fire in California generated post-fire debris flows and flash-floods that killed

23 people, injured hundreds more, and destroyed many hundreds of homes.

Debris flows following a bushfire in 2007 in Victoria washed away roads and left communities stranded. Credit: Adrian Murphy/ Melbourne Water

The number of fatalities resulting from the post-fire debris flow was ten times greater than those resulting directly from the wildfire. Similar events in Australia have destroyed infrastructure and homes, contaminated reservoirs, and resulted in fatalities and injuries to firefighters

Post-fire debris flows in south east Australia are highly sensitive to soil conditions, and have only been observed in areas with shallow, poorly structured soils. When they do occur, they generate thousands of tonnes of fine sediment, most of which is efficiently transported through the river network, ultimately contaminating our water storages.

Fire frequency in forests is increasing world-wide and is likely to increase in the coming decades in south east Australia in response to reduced annual rainfall and increased maximum temperatures, but at the same time the intensity of thunderstorms is also increasing in response to higher temperatures.

Both these changes will increase the frequency and intensity of high magnitude post-fire erosion events and increase the risks to communities and water supplies. Climate oscillations, driven partially by the El Niño/Southern Oscillation (ENSO), are also projected to intensify, with more dry and wet extremes. This, in turn, will lead to more frequent "evacuation" of sediment stored in upland valleys and channels, which will end up in our reservoirs.

Fire-related soil erosion leaves an observable legacy in our steep mountainous uplands, with shallower soils in areas that are vulnerable to post fire erosion, compared to areas with less fire and more resistant soils.

In fact, over longer timescales, our recent research has found that forests, soils and wildfire actually "co-evolve" together, generating positive feedbacks that can further accelerate the direct effects of climate change on catchments.

Fire related erosion results in shallower soils, that in turn favor more open canopied forests that allow the understory fuels to dry out and burn, creating a positive feedback, whereby more fire begets more fire.

Researchers from Swansea University, the University of Melbourne and the United States Forest Service monitoring soil erosion following a bushfire in the Thompson catchment (Melbourne's main water supply) in 2018 as part of an international collaboration. Credit: Gary Sheridan, University of Melbourne

These patterns are particularly strong in the south east Australian climate, which straddles a climate "tipping-point," resulting in strongly asymmetric patterns of north and south facing soils, forests and slope geometry. There is just enough difference in sunshine on these opposing slopes to push the more exposed slope into the positive feedback loop described above.

So what should we do? The risks from bushfires and storms is increasing, and we need to respond to this increasing risk now.

The long-term solution is of course to reduce greenhouse gas emissions. However, considerable change is already unavoidable, even with the most ambitious climate change responses.

There are many things that can be done to reduce the risk, through fire prevention, mitigation of post-fire erosion and adaptation through upgrades to our water supply systems. Fire prevention strategies include fuel management, strategies for first-attack, strategic fire breaks and maintenance of road networks for access to remote areas in water supply catchments.

In the event of a bushfire, which really is inevitable over the next few decades, risk mitigation may include erosion and debris flow control on hillslopes to stop the soil washing away, check dams to trap the soil, and mechanisms for diverting dirty water.

Adaptation may include upgrades to treatment facilities, investment in new water supplies and infrastructure to support strategic redistribution of water supplies. The reliability of redistribution however becomes more limited when reservoir storages are low, which unfortunately often coincides with drought and fire.

Better risk assessments can be used to prioritize limited resources for protecting water supplies. Ongoing research is required to inform planning and policy development in rapidly changing environment.

Governments and policy makers will increasingly need draw on all of these to ensure community safety and uninterrupted water supplies to our cities and towns in a hotter, drier future with more severe fires and intense rainfall events.

More information: The role of fire in the coevolution of vegetation, soil and landscapes in south eastern Australia. hdl.handle.net/11343/213469

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