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Retaining deadwood in disturbed forests reduces changes to soil fungal communities and promotes regeneration

Issue 586: Events such as storms that cause significant damage to forest trees have obvious effects above ground. What happens below ground is less apparent, and less studied.

Photo by Jürgen Bauhus, Shutterstock

Knowledge of impacts on fungal communities and carbon stocks, however, is important for informing optimal management. In particular, the symbiotic fungi that help trees to grow can be negatively impacted by disturbance, new research shows – which could be key in natural forest regeneration.

Between 1970 and 2010, the amount of timber taken from European forests affected by windthrow and bark-beetle attacks doubled – problems predicted to increase further with climate change. Disturbance can abruptly change forest structure and habitat. Deadwood, for example, promotes species richness. However, since dead and damaged trees may encourage further insect outbreaks and other disturbance events (e.g. windthrow), restrict access for machinery and provide a revenue opportunity, managers often remove them (known as 'salvage logging'). Harvesting operations cause further disturbance – for example, when machinery compacts soil.

Some fungi need rotten wood to produce fruiting bodies, and previous studies have offered evidence that they are negatively affected by salvage logging, but overall there is little research on how disturbance affects the soil microbiome. Meanwhile, since they decompose organic matter, changes in fungal communities can alter soil carbon and nitrogen dynamics.

To explore the response of fungal communities to disturbance, researchers carried out sampling in 21 intact and disturbed plots across Germany's Bavarian Forest National Park, which was affected by a hurricane in 2007 and, later, severe outbreaks of bark beetle (*Ips typographus*). The plots were all dominated by Norway spruce (*Picea abies*). Half the disturbed plots had been salvage logged with machinery; the other half retained fallen/attacked trees, leaving large amounts of deadwood.

The researchers measured ergosterol (the main steroid in fungi, not found in plants) in soil as a proxy for fungal biomass, recorded the relative abundance of different types of fungi, and looked for six enzymes involved in decomposition of organic matter, as well as carbon and nitrogen.

Overall, fungal biomass declined as the volume of trees on the site dropped. Intact plots were dominated by ectomycorrhizal fungi (e.g. *Clavulina* and *Russula*), which are symbiotic, relying on carbon from host trees. They form a net (a hyphal sheath) around tree roots which helps the tree to take up water and minerals, while the fungus is given access to sugars from the tree.

Saprotrophic types of fungus (e.g. *Mortierella*) – which take energy from decomposing matter – were most abundant in disturbed plots. These are thought to be most efficient at decomposition of organic matter, but many species of ectomycorrhizal fungi also contain enzymes that can degrade cellulose, chitin and lignin. Nutrients they derive from such organic matter may also be shared with their associated trees, promoting their growth.

Relative abundance of ectomycorrhizal fungi declined from 67% in intact stands to 28% in salvage logged plots, with notable reductions in *Russula*, *Amanita* and *Lactiflorus*. The shift can be explained by the vast reduction in mature host trees after disturbance, say the researchers.

Relative abundances of each type of fungus were similar in salvage-logged and deadwood- retention plots. However, certain groups were correlated with higher amounts of deadwood and standing trees, perhaps due to the positive effect on regeneration in plots with minimal intervention. Deadwood can protect saplings from being eaten by animals, for example, while machinery compaction may be detrimental for some fungus. Since ectomycorrhizal fungi enhance tree growth, deadwood may be beneficial for ecosystem recovery following disturbance.

Coinciding with changes in fungal communities, the researchers found activity of enzymes that degrade organic matter reduced by 30–80% following disturbance. Interestingly, the relative increase in saprotrophic fungi did not lead to greater decomposition – although they possess greater enzymatic potential than ectomycorrhizal. The researchers note that reduced enzymatic activity may in fact favour the recovery of soil carbon and nitrogen stocks after disturbance, as these can decrease if decomposition rates exceed organic matter input.

Disturbances that reduce the amount of woody biomass in forests have profound effects on soil ecology. Retaining surviving trees and deadwood can significantly reduce changes, conserving fungal communities and maintaining decomposition processes, the researchers conclude.

Further Information

Storm-damaged trees with snapped trunks are a key target for bark beetle; low resin pressure in the stem results in less ability to repel attacks. Trees with significantly intact roots are not at high risk and neither are older, dead trees.

Source:

Mayer, M., Rosinger, C., Gorfer, M., Berger, H., Deltedesco, E., Bässler, C., Müller, J., Seifert, L., Rewald, B. and Godbold, D.L. (2022) Surviving trees and deadwood moderate changes in soil fungal communities and associated functioning after natural forest disturbance and salvage logging. *Soil Biology and Biochemistry*, 166: 108558. Available from: https://doi.org/10.1016/j.soilbio.2022.108558

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