Untangling the effects of soil properties on methane oxidation

Kerryn J. McTaggart, T.L Bell, C.J. Weston, L.T. Bennett

School of Forest and Ecosystem Science, The University of Melbourne, Creswick

1. Fire rapidly changes soil properties
Although the effects of fire on soil properties is well known, less is understood about the effects of these changed soil properties on soil processes. One such important process is methane (CH$_4$) oxidation, particularly with aerobic forest soils being important sinks of atmospheric CH$_4$. Before understanding the effects of fire on CH$_4$ oxidation, a better understanding of the effects of individual soil properties on CH$_4$ oxidation is needed.

Methods
Soils cores were incubated in specially modified fowlers jars. Changes in headspace CH$_4$ was measured using a gas chromatograph.

Sites
Soil was collected from Alpine ash (Eucalyptus delegatensis) forest, Bogong High Plains, Victoria. Wildfires in 2003 and 2006 caused crown death of dominant trees in some areas and removal of the understorey vegetation in others.

2. Potential methane oxidation varies in the soil profile
Differences in CH$_4$ oxidation rates within the soil profile could not be explained purely by the differences in individual soil properties (Figure 1).

Differences in net CH$_4$ oxidation rates may be explained by:
- differences in methanotroph composition and abundance,
- limitation of methanotroph growth and activity by low CH$_4$ concentration,
- differences in soil properties with depth (i.e. inhibition by inorganic N),
- competition for resources with other soil bacteria.

3. Soil surface area and bulk density affects CH$_4$ oxidation
Intact soil cores of 0-10 cm showed less CH$_4$ oxidation than the sum of cores from 0-5 and 5-10 cm (Figure 2), suggesting that increased surface area to volume ratio allows more CH$_4$ to diffuse into the soil.

Although intact soil better represents field conditions, sieved soil can be more accurately manipulated. No significant difference was detected between CH$_4$ oxidation of intact and sieved soil from the same depth (Figure 2) suggesting that sieved soil can be used in laboratory incubations to determine factors controlling oxidation.

4. Effects of soil moisture on methane oxidation
Soil samples adjusted to 30 and 45% WHC showed the greatest CH$_4$ oxidation suggesting this is the optimal range for both methanotroph activity and CH$_4$ diffusion (Figure 3). Oxidation was reduced by moisture-limited methanotroph activity or water-limited diffusion of CH$_4$.

Figure 2: Differences in methane oxidation between intact soil (of different SA:V) and sieved soil. Values are means ± se, n = 10. SA:V = surface area to volume ratio. Intact soil was collected from the field with minimal disturbance. Gravimetric soil moisture differences were within 8%.

Figure 3: Variation in methane oxidation with soil moisture (soil adjusted to % of water holding capacity; WHC). Each point is the mean of three replicates of the same soil sample.

5. Conclusions and future work
Methane oxidation rates are controlled by methanotroph composition, abundance and activity, which are influenced by soil properties.

Further research is needed to build a model to predict the effects of fire and climate change on CH$_4$ oxidation rates. This project aims to explore CH$_4$ oxidation kinetics, temperature and inorganic nitrogen effects, field CH$_4$ rates (e.g. manipulation of field soil properties) and the composition of the methanotroph populations (using molecular studies, T-RFLP).