Nitrous oxide and methane flux in grazed pasture and forest systems in southern Australia

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Methane and Nitrous oxide contribute more than 25% of Australia's greenhouse gas emissions, the majority of which comes from the agricultural sector. In the southern states of Australia, large areas of pastoral land have been afforested to eucalypt plantations. These afforestations have direct and indirect impacts upon the regional greenhouse gas balance through net C sequestration in foliar and woody biomass, reduced soil N_2O and CH_4 emissions as compared to pastoral systems (soil and animals) and increased soil CH_4 uptake as compared to pastoral land. We measured the temporal (multi-seasonal) variability of in N_2O and CH_4 fluxes using an automated measurement system installed in contrasting land-use systems near Ballarat, Victoria and then near Albany, Western Australia. At each site, the land-use systems studied were a pine plantation, a blue gum plantation, grazed pastoral land and a remnant woodland (WA only).

In Victoria, there was little difference between N_2O and CH_4 flux in the plantations (pine and eucalypt) and the extensive, unimproved pasture system. N_2O emissions were small in all land-use systems, < 5 ug N_2O -N m^{-2} h^{-1} throughout the year. CH_4 uptake rates were greater, ranging from 20 to 30 ug CH_4-C m^{-2} h^{-1} in summer to as little as 5 to 17 ug CH_4-C m^{-2} h^{-1} in winter. Seasonal CH4 uptake rates and weak N2O emission rates were related to higher soil moisture contents in all land-use systems.
In Western Australia, there was a considerable difference between the N_2O flux in the improved pasture as compared to the forest systems (pine, eucalypt and remnant woodland). Improved pasture management included establishing a clover/ryegrass sward mix and annual phosphate/potash (3:1) additions at 100 kg ha-1 a-1. Seasonal N_2O flux from the pasture ranged from 14.3 ug N_2O-N m^{-2} h^{-1} in spring/summer to 45.7 ug N_2O-N m^{-2} h^{-1} in autumn. This compared with seasonal N_2O flux of < 3.0 ug N m^{-2} h^{-1} throughout the year in the forest systems, similar to the rates measured in Victoria. In Western Australia, the seasonal CH_4 uptake rates were greater in the forest systems (-5 to -17 ug CH_4-C m^{-2} h^{-1}) than in the pasture (-0.5 to 5 ug CH_4-C m^{-2} h^{-1}). In contrast to the Victorian pasture, CH_4 uptake in the WA pasture system decreased with decreasing soil water content. The CH_4 uptake rate in the undisturbed remnant woodland (*E. marginata* and *C. frasearana*) was approximately double that in the recently established eucalypt and pine plantations.

This study suggest that N_2O emissions are small in both managed and natural forest systems, and that N_2O emissions from pasture systems increase when improved through clover introduction, higher stocking rates and fertiliser application to maintain productivity. On an annual basis, CH_4 uptake was significantly greater in the forested systems than the pasture systems, because of large winter soil water contents or increased summer soil NO_3 availability (WA only).