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Soil nitrous oxide emissions increase temporarily, whilst soil methane fluxes change little, after clearing savanna woodland for agriculture in tropical northern Australia

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Northern Australia may experience future land-use change from savanna to agriculture to provide food security in response to climate change and export opportunities. Clearing tropical savanna leads to large vegetation carbon losses, from fire and decomposition, but may also lead to net methane (CH_4) and nitrous oxide (N_2O) emissions during and after the clearing event. There is great uncertainty as to the impact of vegetation clearing upon CH_4 and N_2O soil exchange processes in tropical savannas.

We measured soil CH_4 and N_2O flux periodically over 18 months using static manual chambers near Katherine, Northern Australia. A 295 ha area of savanna woodland was cleared after 6 months. Savanna soil ranged from being a mean CH_4 sink of -2 to -12 μg C m^{-2} h^{-1} in the dry season, to being a mean CH_4 source of 5 to 10 μg C m^{-2} h^{-1} in the wet season. Of the 72 manual chambers in the adjacent savanna woodland (n=36) and cleared savanna area (n=36), some were always a net CH_4 source, and emissions were greater close to trees (<2 m distance) than in the open. Savanna clearing had no obvious impact upon soil CH_4 flux rates. Savanna woodland soil was a weak N_2O source (<5 μg N m^{-2} h^{-1}) that increased significantly up to 23 μg N m^{-2} h^{-1} in the weeks after clearing, but only in areas of soil disturbance. Soil N_2O emissions returned to rates comparable to those measured in savanna woodland in the following dry season.

The seasonal sink-source variation in savanna soil CH_4 exchange is due to the net balance of 1) soil CH_4 uptake by methanotrophic bacteria, 2) soil CH_4 emissions by soil methanogenic bacteria during the wet season, and 3) localized CH_4 emissions from soil termite activity. Greater soil CH_4 emissions near tree stems probably indicate greater localized termite activity. The temporary increase in soil N_2O emissions was only apparent in disturbed soil and may reflect a breakdown in normal soil N transformation processes or enhanced mineralisation of fresh organic matter. Soil N_2O emissions could be reduced by minimizing the area of soil disturbed by land clearing machinery. However, this increase in soil N_2O emissions was negligible when compared to soil and vegetation C losses that were many orders of magnitude greater. Our study demonstrates that non-CO_2 greenhouse gas emissions are of minor importance following clearing events in tropical savannas in Australia. The longer term impact of land clearing upon soil CH_4 and N_2O exchange processes will be greatly influenced by subsequent termite activity and subsequent soil moisture and temperature regime supported by the agricultural management system.