Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.16897

Linking soil phosphorus to soil greenhouse gas emissions in humid, subtropical forests

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The cycling of phosphorus (P) between plants and soil has implications for CO_2 and CH_4 emissions. However, there is a gap in our knowledge of how plant type will shift CO_2 emissions through P availability. We investigated this relationship at two alluvial terrace sites, one in a stand of drought-tolerant post oak (*Quercus stellata*) trees and the other in cherry bark oak (*Quercus pagoda*) trees. Topography, parent material, and soil texture are similar at these two sites. The cherry bark oak stand has ~6x higher available soil P (0.86 mmol kg^{-1}) compared to the post oak stand (0.15 mmol kg^{-1}). Conversely there is 4x less P stored in the cherry bark oak wood, compared to the post oak wood. We hypothesize respiration is P limited, and with less demand for P in the cherry bark oak trees, there is more available P in the soil resulting in higher CO_2 emissions through either heterotrophic or autotrophic respiration. To test this, we measured the apparent respiratory quotient (ARQ) which tracks the difference in soil CO_2 and O_2 relative to atmospheric conditions at four depths, as well as surface CO_2 and CH_4 fluxes.

The mean ARQ for both stands was < 1 from January through April and > 1 for May through July. These seasonally dependent changes in ARQ may reflect Fe redox reactions and silicate weathering during the winter and spring and aerobic respiration during the late spring and summer. Further, the mean ARQ was greater in the subsoil (Btg) horizon under the cherry bark oak forest, suggesting that more CO_2 was produced than O_2 consumed. This is consistent with our preliminary flux measurements collected from summer to fall showing that there are significant differences in soil CO_2 (p-value < 0.001) fluxes across stands. The cherry bark oak stand has higher soil CO_2 (6.2 $\mu mol/m^2/s$) emissions than the post oak stand (2.5 $\mu mol/m^2/s$). Taken together our findings are consistent with previous work; it suggests that changes in the forest ecology, such as changes in dominant tree species, may have an impact on soil CO_2 emissions through P cycling in the plant-soil continuum.