# Experimental evidence for the role of land plant evolutuion in the intensification of mineral weathering

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The emergence of trees with deep and complex roots over the Devonian Period represents the most important biotic feedback on the geochemical carbon cycle to appear during the evolutionary history of land plants. The feedback fundamentally rests upon the effect of trees on rates of continental mineral weathering to meet plant nutrient demands. Enhanced dissolution of Ca-silicates increased the flux of $Ca^{2+}$ to the oceans, ultimately resulting in massive declines in atmospheric $CO_2$ ($[CO_2]_a$) via well-established carbon cycle mechanisms. Critically, the associated evolution of symbiotic arbuscular mycorrhizal (AM) fungi in concert with roots over the last 410 Myr likely intensified weathering rates. AM fungi are particularly effective at unlocking the limiting nutrient phosphorus in soils via Ca-phosphate dissolution that subsequently led to elevated productivity and biomass of early terrestrial ecosystems, and the later emergence of forests.

Here I draw together evidence from field studies and controlled-environment experiments linking the evolution of land plants and their mycorrhizal fungal partners – from early emerging, non-vacular lineages to gymnosperm and angiosperm trees – to a mechanistic understanding of plant-driven weathering at the interface between substrate minerals and growing tips of roots and fungal hyphal networks. The evidence is underpinned by the concept that delivery of plant-fixed carbon-energy belowground via roots and mycorrhizal fungal partners drives plant-soil interactions and mineral weathering. Our research synthesises novel experimental approaches to develop understanding of the effects, interactions and associated feedbacks of $[CO_2]_a$, stature and biomass, and the evolutionary advancement of plants and their mycorrhizal partners, from ancestral AM fungi to more evolutionary advanced ectomycorrhizal fungi, on plant-driven weathering and interactions with minerals across the Phanerozoic.

Our experiments have important implications for understanding how large-scale fluctuations in Earth's $[CO_2]_a$ over geologic timescales have been mediated by broad trends in the evolution of the belowground parts and symbiotic partnerships of land plants.