Resolving the Paradox of Post-fire Forest Recovery in the Greater Yellowstone Ecosystem: The Importance of Subsurface Nitrogen Cycling

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Introduction

Despite low measured inputs of nitrogen (N), and no commensurate declines in total soil N, **regenerating lodgepole pine (*Pinus contorta*) *accumulate large quantities of N during* post-fire forest recovery** in the Greater Yellowstone Ecosystem (GYE). To address this, we sought to test a modified version of the "N Bank" hypothesis (Lovett et al. 2018):

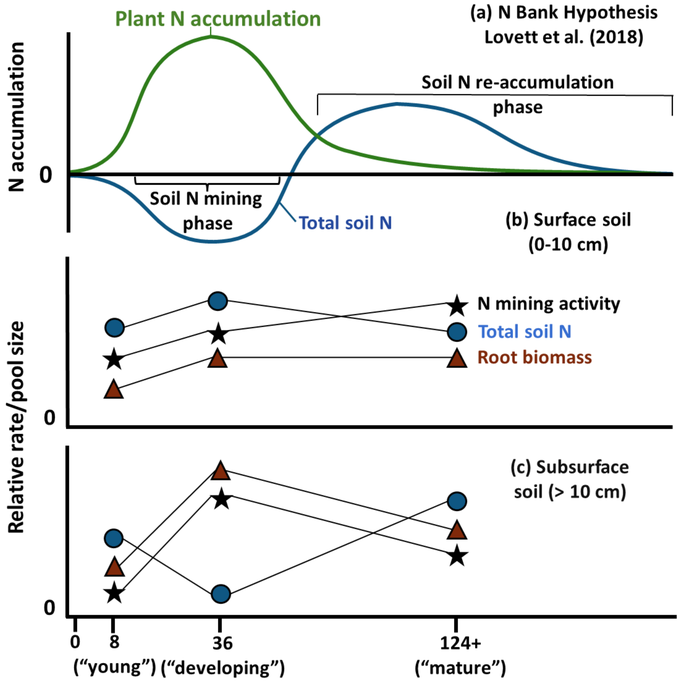

Fig 1. Conceptual diagram representing our hypothesized changes in surface (b) and subsurface (c) soil N pools and dynamics across three forest stages. (a) Our overarching hypothesis taken from Lovett et al. 2018).

Methods

Three 50 x 50 cm soil pits in lodgepole pine stands **of each forest stage (Fig 1)** growing on rhyolitic inceptisols in Yellowstone and Grand Teton National Park (Wyoming, USA).

Soils sampled every 10 cm to 1 meter for measurements of:

1. Bulk density, root biomass and total soil N
2. Inorganic N and N mineralization rates
3. Potential N-acetylglucosaminidase (NAG) activity via fluorescence
   a) methylumbelliferone (MUB) assays (*sensu* German et al. 2011)
4. Potential nitrogenase activity via Acetylene Reduction Assays (ARA)
   a) 18–22-hour assays under field temps (*sensu* Reed et al. 2007)

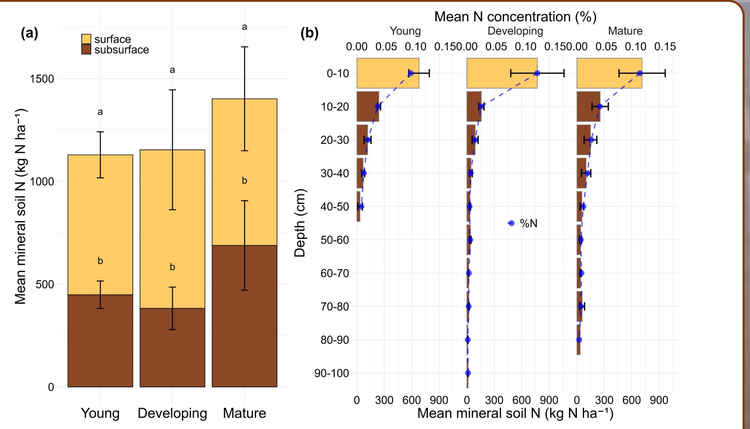

Fig 2. Total soil N pools and concentrations (a) Mean mineral soil total N pools (± 1 SE) in surface (< 10 cm) and subsurface (> 10 cm) mineral soils across the three forest age groups (n = 3). Letters indicate differences among pools (Tukey, P < 0.05). (b) Total N pools (columns and error bars ± 1 SE) and concentrations (dots) for each 10 cm depth increment.

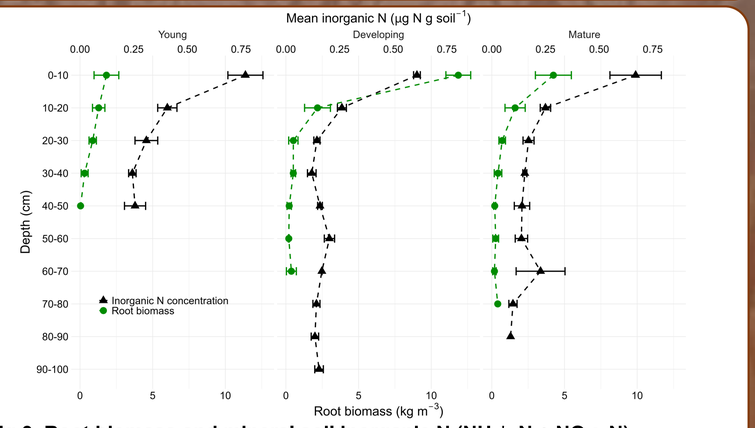

Fig 3. Root biomass and mineral soil inorganic N (NH_4^+–N + NO_3^-–N) Mean root biomass (green circles) and soil inorganic N concentrations (black triangles) by depth across lodgepole pine forest stages in the GYE. Values represent means ± 1 SE (n = 3).

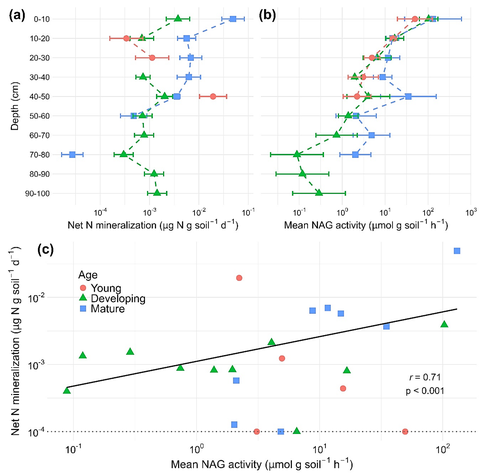

Fig 4. Potential N mineralization and NAG enzyme activity

(a) Mean soil net N mineralization rates by depth across forest stages (n = 3). (b) Mean soil NAG activity in mineral soil by depth across forest stages (n = 3). (c) Scatter plot showing Pearson's correlation between net N mineralization rates and NAG activity in across sites. (a) and (b) values depict means ± 1 SE.

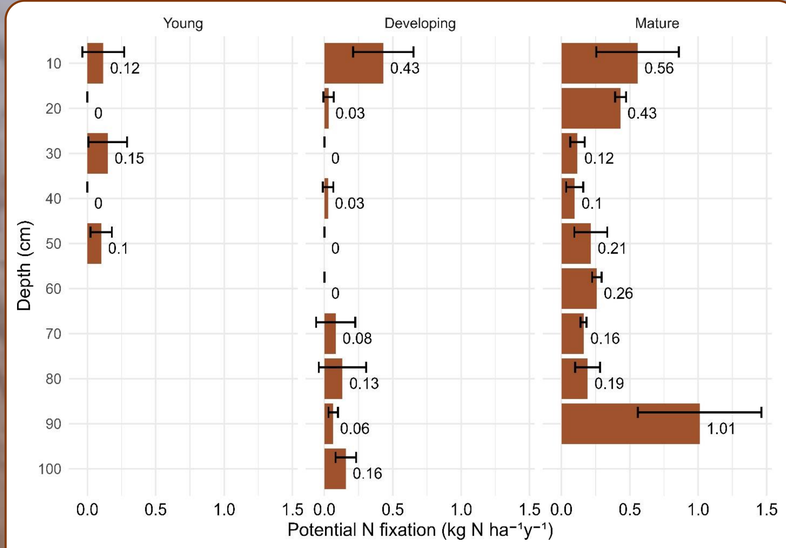

Figure 7. Potential soil N fixation rates across depths and forest stages of lodgepole pine dominated soils in the GYE. Rates are calculated using 3.1 molar C_2H_4: N_2-fixed conversion ratio. N fixation estimates were scaled assuming a constant N fixation rate per depth throughout the year. Values depict means ± 1 SE (n = 3).

Evidence for the N bank hypothesis?

1) **Little evidence of soil N decline during peak N demand – detecting changes across succession is difficult**

2) **Developing forests have more surface root biomass relative to other stages (N-mining?), yet mature forests have higher N mineralization rates**

3) **Subsurface soils in mature forests have the potential to fix quantities of atmospheric N that rival rates of atmospheric N deposition. <u>Overlooking subsurface soil N fixation may underestimate total N fixation rates in ecosystems broadly.</u>**

Acknowledgements

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