Soil Community Responses to Multiple Co-occurring Forms of Human-Induced Environmental Change

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Research Questions and Hypotheses:

Question: How will soil communities respond to the co-occurrence of altered precipitation patterns and increased nitrogen in Phoenix, Arizona?

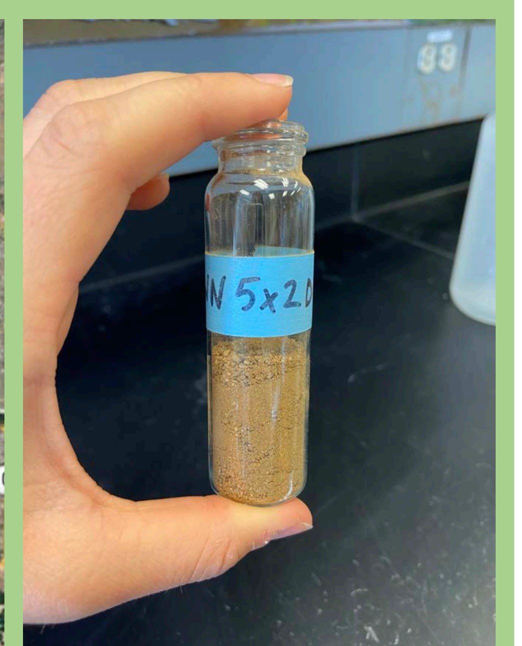
Hypothesis: The activity and abundance of soil microorganisms will increase when subjected to increased precipitation and nitrogen levels.

Introduction:

- Human-induced climate change causes an increase in temperature, as a result of increased greenhouse gases. The change in temperature results in altered circulation patterns that then changes precipitation patterns.
- The Sonoran Desert is expected to see less frequent events that are larger in size, while temperatures are projected to increase by 3-6 ºC in the next hundred years (Brusca et al. 2013).
- Urbanization is also happening rapidly in the Sonoran Desert. This causes an increase in fossil fuel combustion, which results in nitrogen deposition.
- These forms of change are usually studied individually, however, in nature, they are all happening at the same time.
- All of these factors combined will have an impact on soil microorganisms, who are responsible for nutrient cycling and help carry out processes that support plant growth and maintain soil health (Perez-Guzman et al. 2020).
- Because water is already limited in the Sonoran Desert, soil communities may not be reduced as a result of altered precipitation patterns but could instead be changed in activity and abundance (Preece et al. 2019).

Methods:

1. Soil was collected from the DesFert sites at Piestewa Peak (urban soil) and the White Tank Regional Park (rural soil). Half of the soil samples were taken from plots with added nitrogen and the other half from control plots with no added nutrients.
2. 25 grams of soil were placed into 40mL incubation vessels (pictured) and incubated at average Phoenix temperature (30.5 ºC) for eight weeks.
3. Precipitation was simulated by adding water in a fully factorial design to the incubated soils according to natural precipitation patterns, as well as altered precipitation patterns projected for Phoenix, Arizona.
    - **Amount:** 5mm pulse events (average summer size for Phoenix over the past 5 years) and 7.5mm pulse events (50% increase in size) were simulated in the incubation vessels.
    - **Frequency:** Both precipitation amounts were added either every two weeks (simulating the average number of summer events occurring over the past 5 years, spread evenly) or monthly (~50% reduced frequency), to make for four precipitation treatments.
4. Respiration rates were measured every other day using a LI-COR Gas Analyzer for the duration of this project.
5. After the 8-week incubation period, the soil's nitrate, nitrite, and ammonia levels were measured.



Results:

- Piestewa Peak soils had more nitrate/nitrite than did the White Tank soils, and it increased with the more rain they received.
- Piestewa Peak soils with added nitrogen had the highest respiration rates to begin with.
- Towards the end of the 8-week period, soils with 7.5mm pulse events every 4 weeks and 5mm pulse events every 2 weeks had the highest respiration rates.
- Differences in site (P <0.001), fertilization (P <0.001), precipitation (P <0.001), and day (P <0.001) were all significant.
- Differences between site and fertilization (P = 0.017), fertilization and precipitation (P = 0.009), fertilization and day (P = 0.040), and precipitation and day (P <0.001) were also significant.

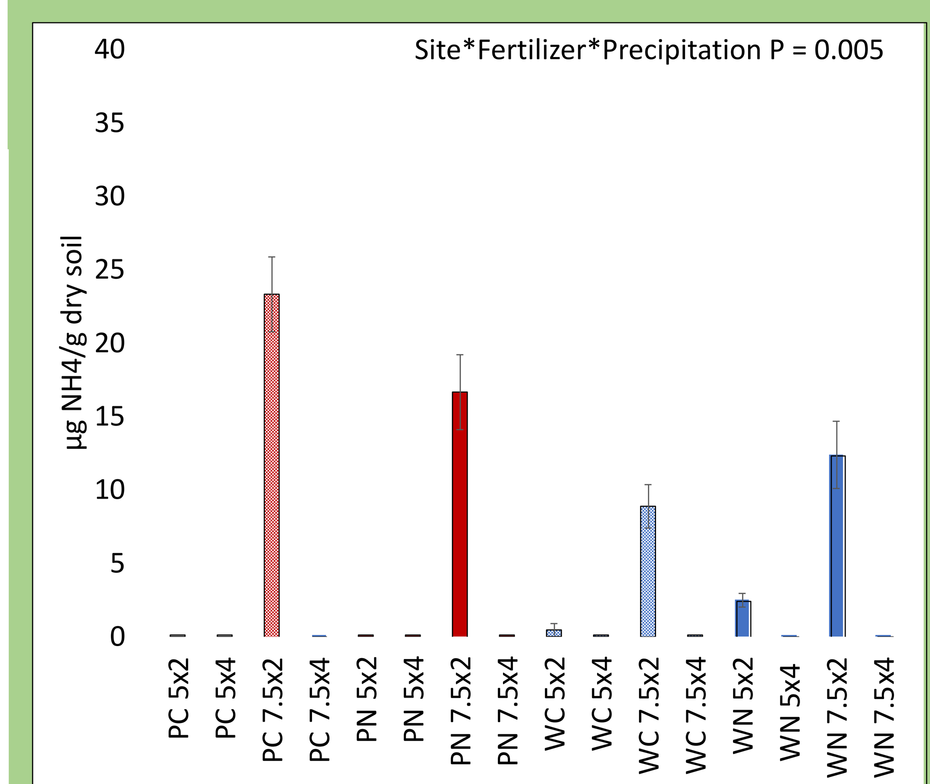


Figure 1. Ammonia levels across all treatments.

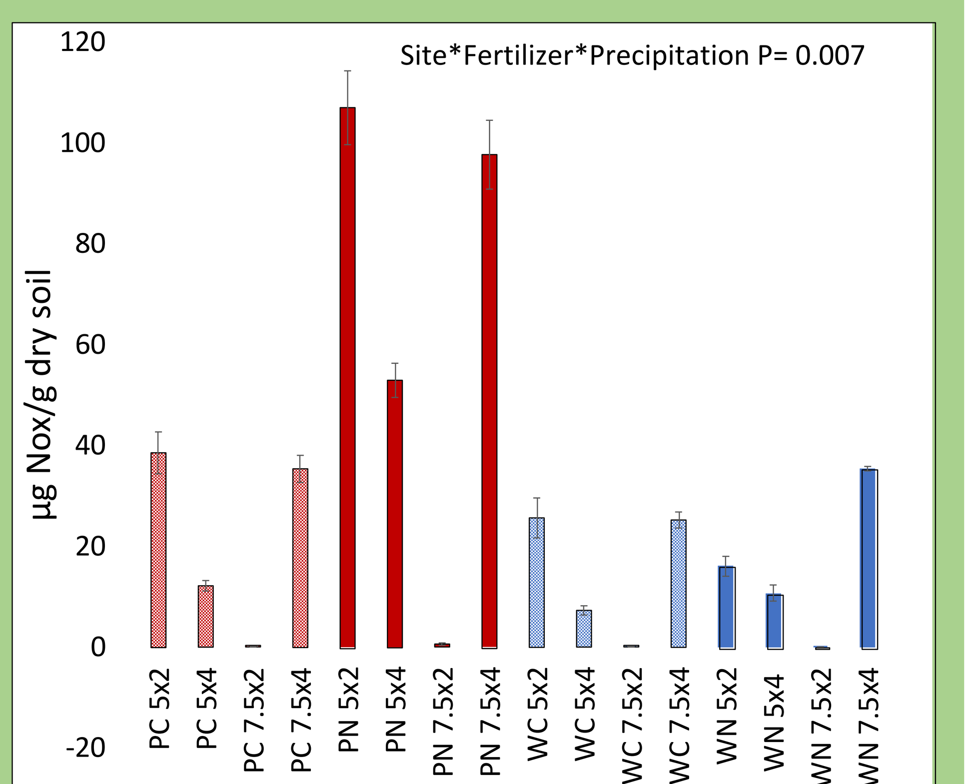


Figure 2. Nitrate and nitrite levels across all treatments.

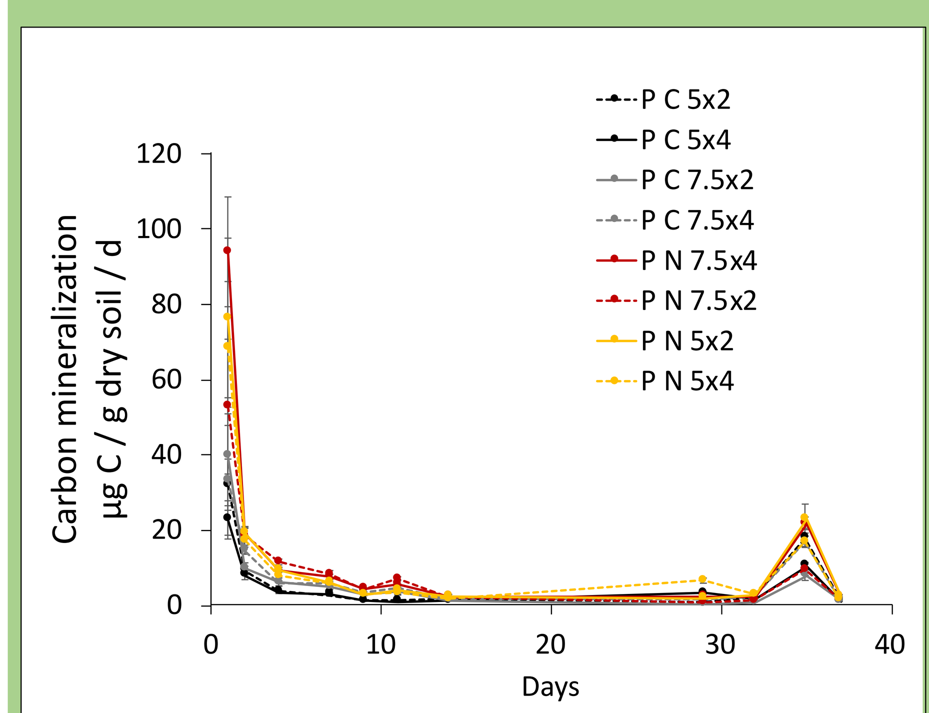


Figure 3. Respiration rates measured on White Tank Regional Park soils during the 8-week incubation period.

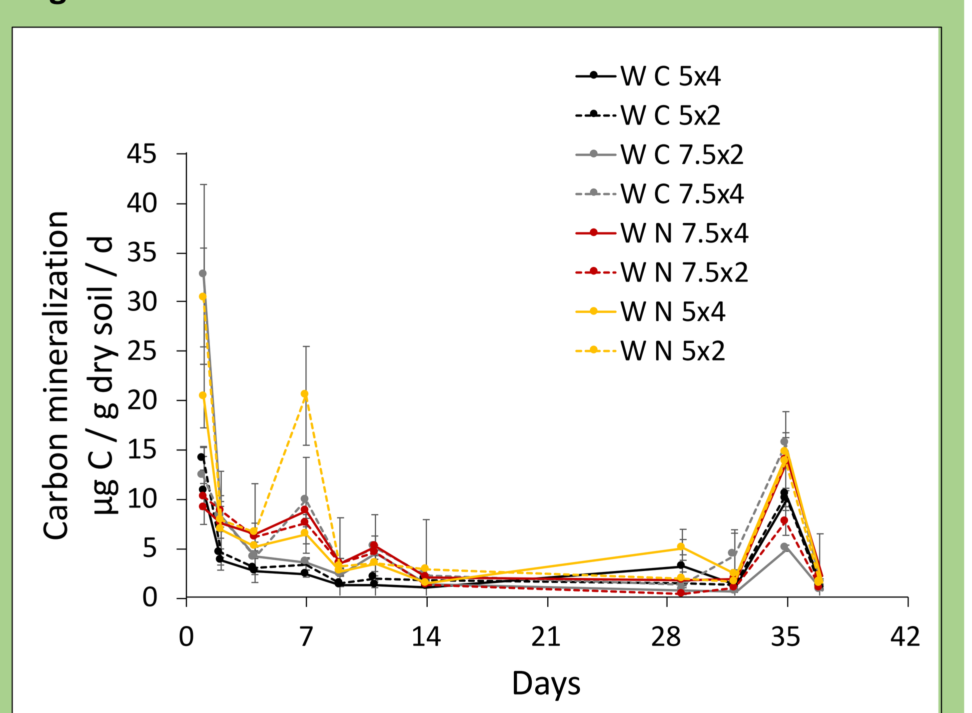


Figure 4. Respiration rates measured on Piestewa Peak soils during the 8-week incubation period.

Discussion:

- Altered precipitation patterns and the addition of nitrogen resulted in changes in soil processes.
    - Soils that received the most rain produced the most nitrate and nitrite, up until they were waterlogged. These soils also had high respiration rates, suggesting the soil microorganisms were more active.
    - Piestewa peak soils with the added nitrogen had high nitrate/nitrate. Though the increase in precipitation helped increase nitrate/nitrite levels, they were still all high regardless.
    - White Tank soils were more affected by precipitation patterns as opposed to the addition of nitrogen. Soils receiving 7.5 mm pulse every 4 weeks produced the most nitrate/nitrate of all the White Tank soil treatments. This is likely because they were getting enough water, but not too much, so the soil microorganisms had the right conditions for them to be the most active.
    - Both Piestewa Peak and White Tank soils had the highest respiration rates with 7.5mm pulse events every 4 weeks and 5mm pulse events every 2 weeks because the soil microorganisms had the right conditions for them to be the most active.
- Urbanization will cause an increase in nitrate/nitrite levels, especially in urban soils.
- The 7.5mm pulse events every 4 weeks that is expected with climate change will cause soil microorganisms to respire more and produce more nitrate/nitrate.

References:

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