Effects of Mesquite Tree *(Prosopis Velutina)* Maturation on Soil Invertebrate Communities and Food Webs

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Introduction

- The Carbon Sink Forest at ASU's West Campus is an experiment testing whether urban forestry as a carbon sink is constructive and practical in a desert city using native mesquite trees (*P. velutina*).
- Urban forest carbon sinks use plant photosynthesis to remove carbon from the atmosphere and are being explored as a solution to anthropogenic climate change (Richter et al.,2020).
- Mesquite trees form mutually beneficial relationships with nitrogen-fixing bacteria.
  - Nitrogen gas is converted to forms of nitrogen usable by other organisms and deposited into soil by fallen leaves (Binkley, 2005).
- Mesquite trees increase soil moisture by lifting water from the water table into soil surrounding their roots (Scott et al., 2008).
- Increased nutrient and water content of soils around mesquite trees theoretically provide food and moisture for a greater number and diversity of organisms, including microbes, nematodes, and microarthropods.
- This research helps build a stronger understanding of the soil food web that processes carbon and other nutrients, by analyzing and comparing pre-existing data of the carbon pools and fluxes, from the microbial flora to the micro- & mesofauna.

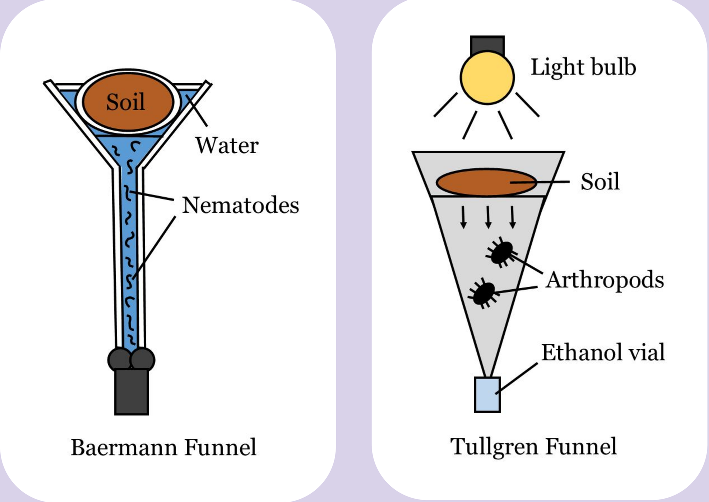
Research Question and Hypothesis

How does species richness within a soil community develop along with maturation of mesquite trees? Being that mesquite trees are nitrogen fixers, how do they affect the nutrient cycle and the food web? Is there a significant impact on any other elements?

If mesquite trees are mutualistic with nitrogen-fixing bacteria, their maturation from a sapling mesquite to a mature tree will shift from a bare soil fungal-dominant invertebrate community and food web to a bacterial-dominant one. Furthermore, the overall species richness and abundance will increase, as well as broaden the range of nutrient cycling.

Methodology

- Collected samples from adult mesquite trees, sapling mesquites, and bare soil from the Carbon Sink Forest at ASU's West Campus (divided into eight zones; one 0.5L soil sample taken from beneath an adult mesquite, a sapling, and bare soil in each zone.)
- Processing and Extraction:
  - 25g of soil tested for water content.
  - 20g of soil preserved with formalin in phosphate-buffered solution for bacterial and fungal cell counts.
  - 50g of soil used for water-based Baermann funnel extraction of mesofauna (nematodes, tardigrades and rotifers).
  - Remaining volume of sample used for heat-based Tullgren funnel extraction of microarthropods.
- Nutrient probes were set out in soil under an adult mesquite, under a sapling, and in bare soil in each zone.
  - Sit for ~1 month to collect ions & measure nutrient cycling beneath adult mesquites, saplings, and bare soil.



Discussion

- Data suggest assumption of initial fungal dominance in bare soil decreasing with maturation of mesquite trees was incorrect (Figure 1).
  - This is consistent with other surveys of Sonoran Desert microbial communities, where bacteria and fungi are much less abundant in bare soil, but bacteria dominates (Kushwaha et al., 2021).
- Cell counts indicate a significant shift in the ratio of bacterial to fungal biovolume as mesquites mature (Figure 1).
  - Mature mesquite forest might therefore have different carbon energetics than the bare soil before it was planted (Binkley, 2005).
- Results show a higher bacterial abundance in the soil beneath adult trees with the increasing species richness and abundance as trees mature (Figure 1, 2).
  - Overall abundance of invertebrates was higher in adult trees likely due to higher moisture and nutrient content.
- No significant difference was found between bare or sapling samples (Figure 1, 3 ,4).
  - Saplings may have been too young to have made a statistically significant contribution to soil nutrient or moisture levels.
  - Future research could repeat these tests on saplings after more years of growth and compare.
- Soil carbon data from 2021 indicates higher average carbon content in soils beneath adult mesquite trees than in bare soil.
  - Taken together with our data, this may indicate that higher amounts of invertebrate feeding and predation in adult mesquite soils contributes to the sequestration of greater amounts of carbon in soil.
- Soil nutrient data collection is ongoing and will shed light on how food web dynamics convert atmospheric carbon to soil carbon.
  - This is the core rationale behind experimentation with urban forestry as an answer to global climate change (Richter et al., 2020).

Results

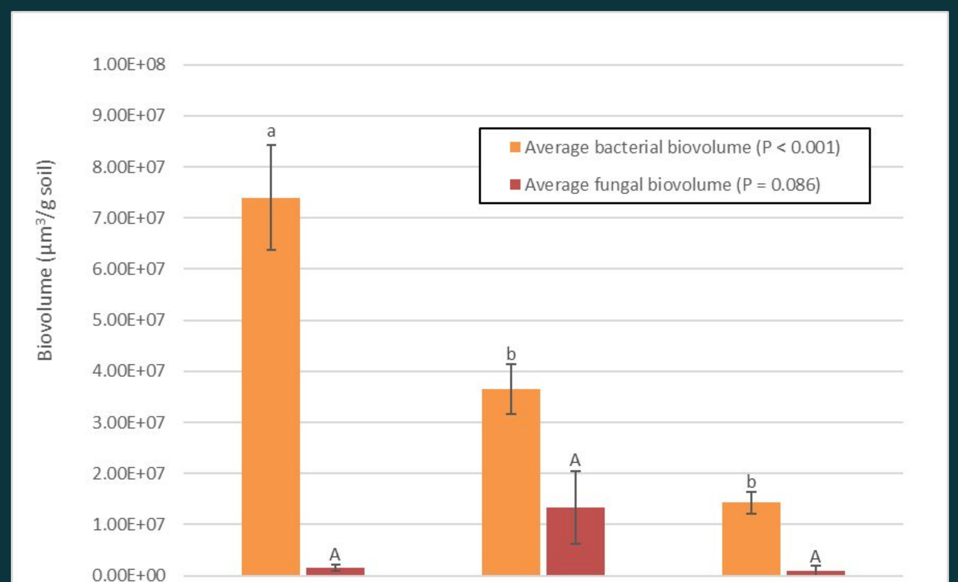


Figure 1. *Bacterial vs. Fungal Biovolume (µm³) per g of Dry Soil.* A significant difference in the bacterial abundance of adult mesquite vs. sapling mesquite or bare soil was identified (a) with no significant difference between sapling mesquite and bare soil (b). There was no significant difference in fungal volume between any sample type (a).
There is significant difference in ratio of bacterial to fungal biovolume between adult mesquite and sapling mesquite (P = 0.034) only. Tukey test represented by labels a-b, A-B.

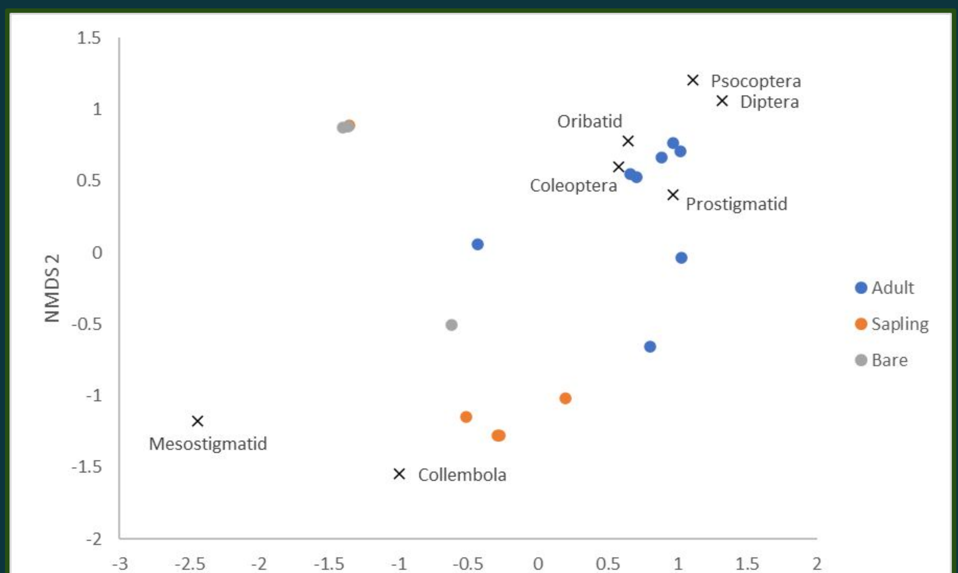


Figure 2. *Arthropod Community Non-Multidimensional Scaling Analysis.* Significant difference between of adult vs. sapling mesquite (P = 0.009) and adult vs. bare soil (P = 0.027). No significant difference between sapling mesquite and bare soil (P = 0.280). Stress = 0.045.
*Not included is the NMDS graph for nematode data - results showed no significant differences (P = 0.333, stress = 0.0976).

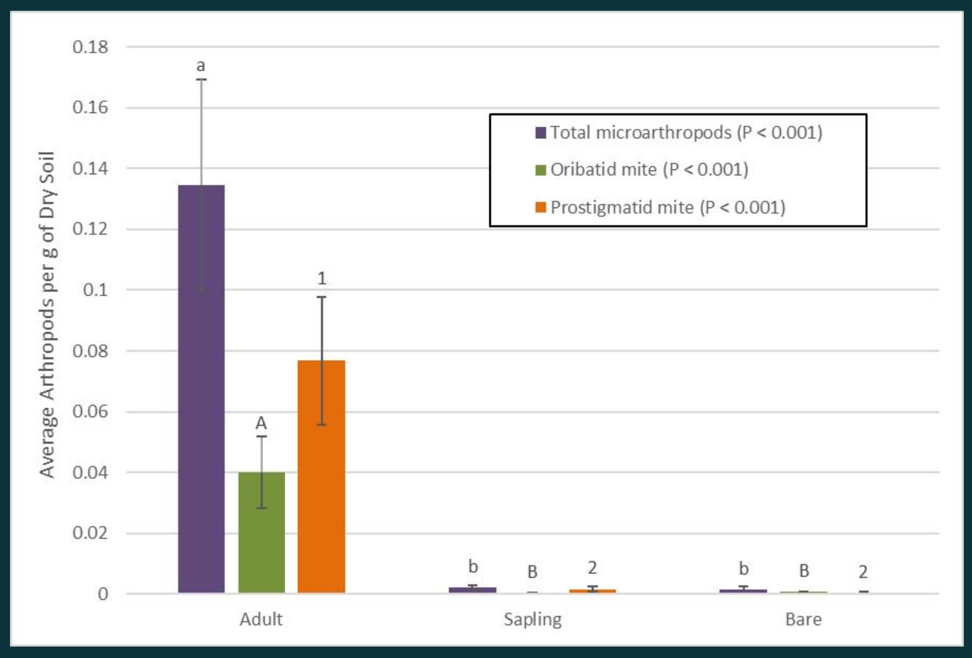


Figure 3. *Average Arthropods per g of Dry Soil.* There was a significant difference in abundance of total arthropods, Oribatid mites and Prostigmatid mites in adult mesquite compared to sapling or bare soil. No significant difference between sapling mesquite and bare soil. Tukey test represented by labels a-b, A-B, 1-2.

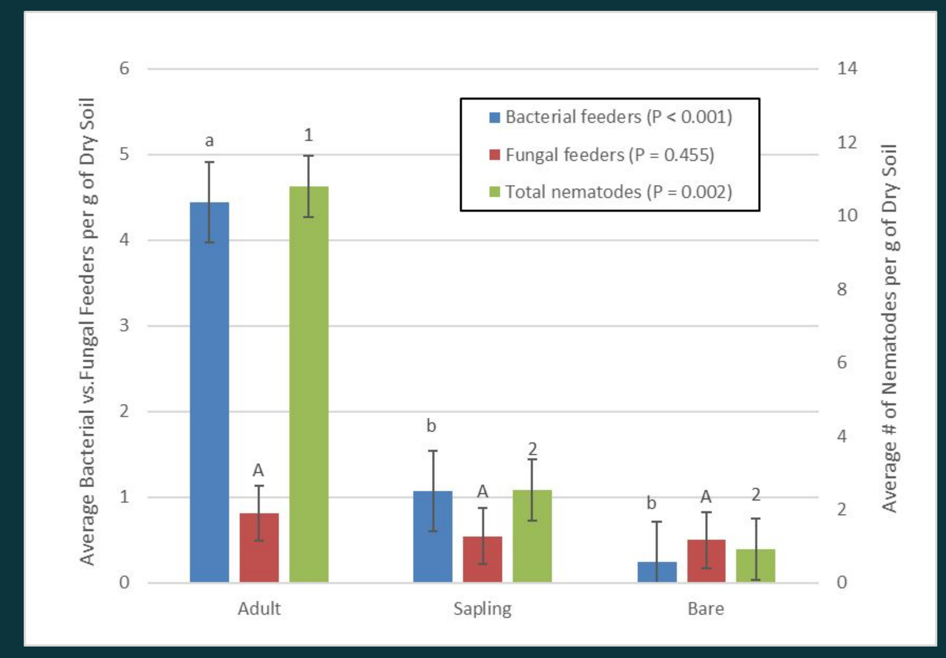


Figure 4. *Average Number of Nematodes per g of Dry Soil* on the right shows a significant difference in the abundance of nematodes in an adult mesquite tree vs. bare soil or sapling mesquite tree (a) and not any significant differences between bare and sapling (b).
Average Bacterial vs. Fungal Feeder Per g of Dry Soil on the left shows significant difference in bacterial feeder abundance between adult and both Bare soil and Sapling mesquite (a), but bare and sapling did not show significant difference (b). Fungal feeders did not significantly differ between sample type (a). Tukey test represented by labels a-b, A-B, 1-2.

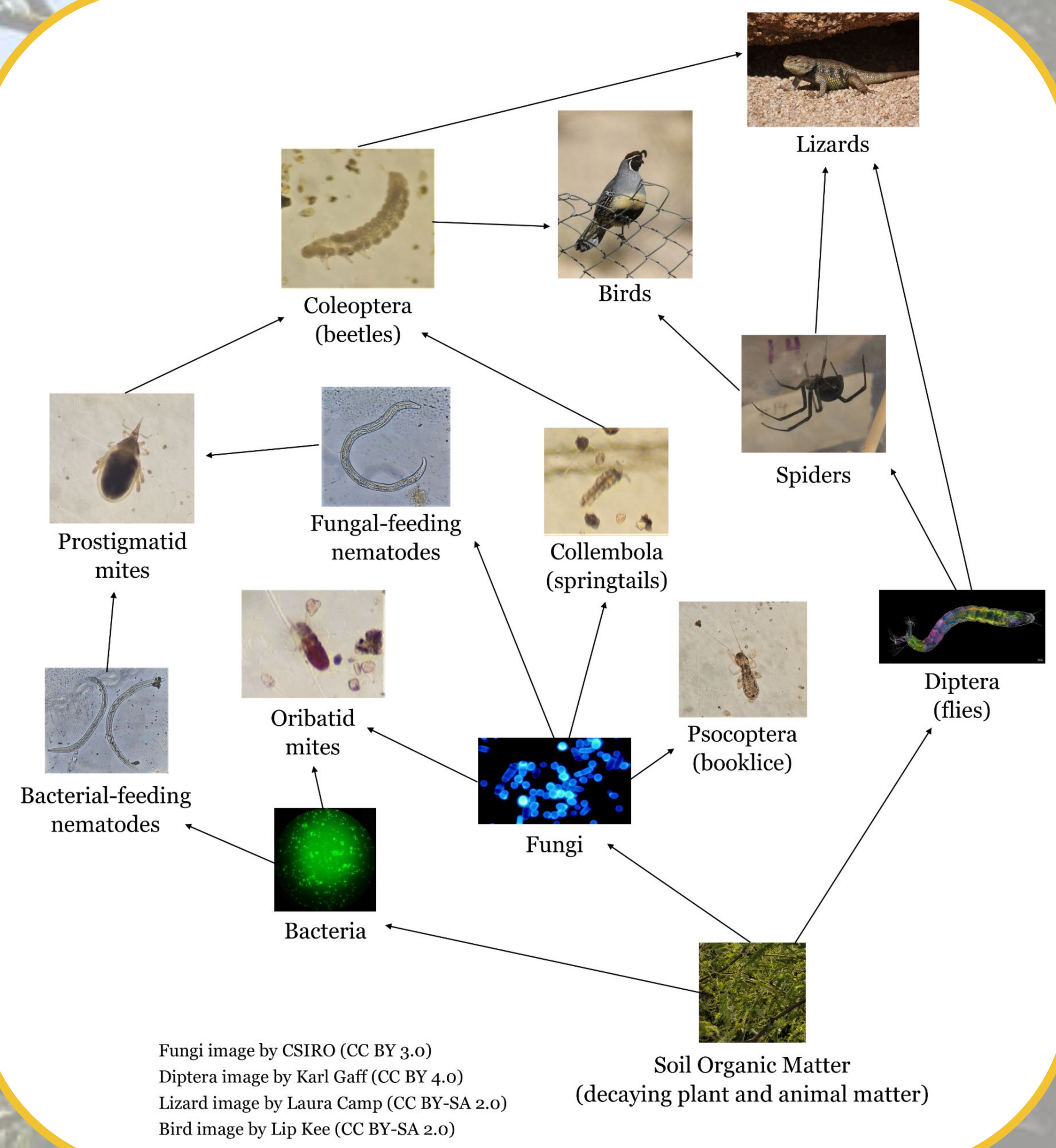


Figure 5. *Carbon Sink Forest Food Web.* Food web illustrates the relationships and nutrient pathways among soil invertebrates living the soils beneath adult mesquite trees, mesquite saplings, and in bare soil at ASU West's Carbon Sink Forest. Invertebrate feeding and predation in belowground environments influence the cycling of critical nutrients, such as carbon and nitrogen, into and out of soil, and can also have direct effects on the aboveground food web as well. *Not pictured are tardigrades and rotifers due to their main food source being algae, which wasn't sampled.

Citations

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The Ball Lab @ ASU - people. Google Sites: Sign-in. (n.d.).

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