2022

Exclusion of Overabundant White-Tailed Deer (Odocoileus virginianus) Results in Shifts in Soil Microbial Communities and Abiotic Soil Condition in a Northeastern Deciduous Forest

Jonathan Chong
Binghamton University--SUNY

Brendan Enochs
Binghamton University--SUNY

Miranda Kearney
Binghamton University--SUNY

Oh Deer!

Exclusion of Overabundant White-tailed Deer Shifts Soil Microbial Communities and Abiotic Soil Conditions in a Northeastern Deciduous Forest

BRENDAN E ENOCHS
JONATHAN CHONG
MIRANDA A KEARNEY
Binghamton University
State University of New York USA

What We Asked

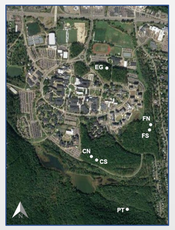
Does complete exclusion of overabundant white-tailed deer lead to changes in soil characteristics and the soil microbiome?[1]

Why We Asked

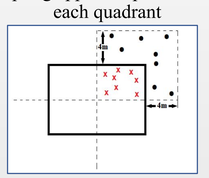
Ungulates alter soil nutrient availability and organic matter pools. Herbivore density is associated with changes in litter quality. Yet few studies have explored whether differences in herbivore densities have measurable effects on the soil microbiome.[2-6]

How We Did It

Location of Exclosures



Schematic of haphazard soil sampling approach performed in each quadrant



Homogenized samples: N=12 (6 sites x inside and outside)

1. Extract DNA
2. Sequence
3. Assign Taxonomy

MG-RAST metagenomics analysis server

BIOL 115 CURE
98 Teams

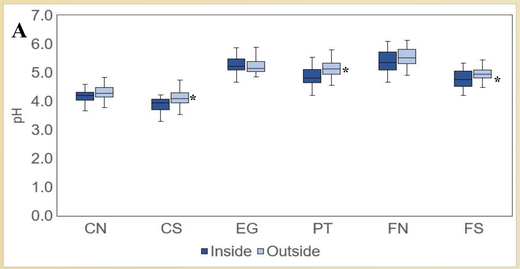
Measure
Vernier probes

pH & Electrical Conductivity

Analysis

PAST
Version 4.03

What We Found



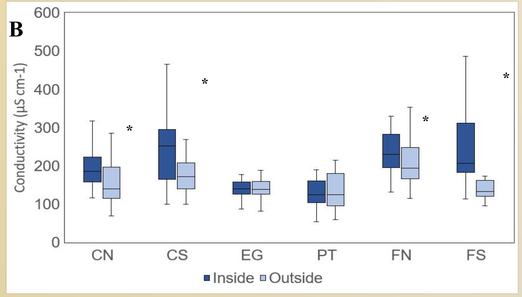


Figure 1: Box plots showing **A.** soil pH and **B.** soil electrical conductivity inside (dark blue) and outside (light blue) of the deer exclosures by site. Samples are listed from left to right as they increase in size of exclosure and decrease in age at sampling. Median is shown as solid line and * indicates a significant difference ($\alpha = 0.05$) using Mann-Whitney U testing between inside and outside.

Deer impacted soils have higher pH & lower electrical conductivity.[Electrical conductivity (EC) used as a measure of soluble salt ions (*e.g.*, Ca^{2+}, K^{+}, Mg^{2+}, Na^{+}, NO_3^{-}) serves as a proxy for nutrient availability.]

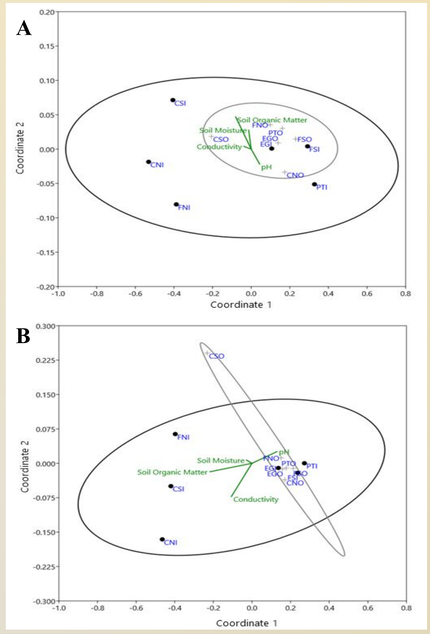


Figure 2: Nonmetric multidimensional scaling ordination plots of the distance between microbial communities based on the Bray-Curtis index. **A.** Compares patterns among dominant community members (Stress = 0.0045); **B.** Shows patterns when dominance is minimized (Stress = 0.0149). The ellipses represent the samples which were within a 75% confidence limit of the centroids.

Structure of soil microbial communities vary. Deer-impacted soils more closely resemble other deer impacted soils. Deer-excluded soils show more variability in community structure.

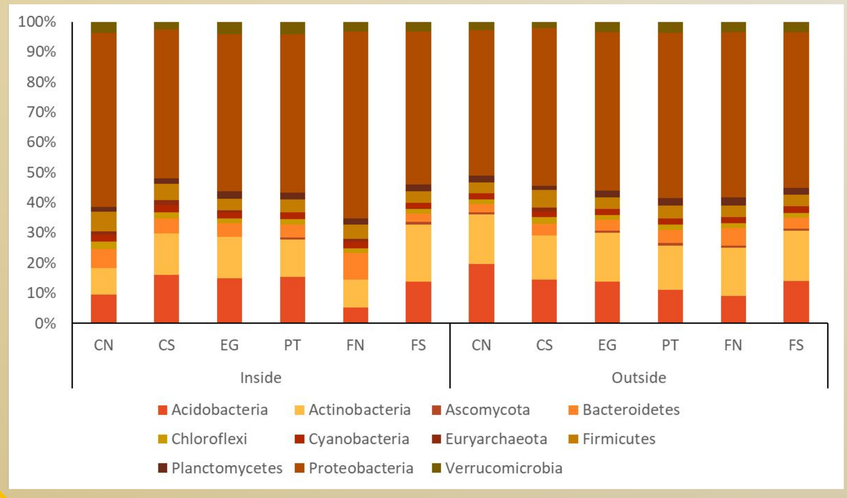


Figure 3: Stacked column bar graph of the top 10 most abundant microbial phyla across soil samples. Samples are grouped by sample location. Paired sites (CN & CS, EG & PT, FN & FS) are listed from left to right as the size of exclosure increases and age of exclosure at sampling decreases. Taxa are reported in alphabetical order moving from the bottom to the top of each column. Relative abundance data was analyzed by using MG-RAST against the SEED database and then visualized using Microsoft Excel Software (Microsoft, Seattle, WA, U.S.A.)

***Ascomycota* one of the 10 most abundant phyla in deer-impacted soils (5 of 6 samples).**

***Euryarchaeota* one of the 10 most abundant phyla in deer-excluded soils (4 of 6 samples).**

What It Means

- Overabundant deer may have **a homogenization effect on the soil microbiome** likely through the regulation of nutrient and plant litter resources accessible to microbial communities.
- When overabundant deer are excluded, the **microbial communities begin to shift**, suggesting that there is the potential for recovery of highly affected soils or perhaps, a shift towards alternative stable states.

What's Next

- The impacts of age and exclosure size on soils affected by overabundant deer.
- More detailed analysis of the role of nutrient additions and resource changes from deer and how that relates to microbial community structure and function may elucidate the mechanisms driving the homogenization effect of deer on the soil microbiome.

Who We Want to Thank

D. Horvath, the Steward of Natural Areas at Binghamton University, for his knowledge on deer dynamics in the preserve and assistance collecting soil samples; all individuals past and present who worked to establish and continue to work to maintain the deer exclosures on campus; and all of the graduate and undergraduate teaching assistants and students in BIOL 115 at Binghamton University, who collected some of the data presented here as part of their class project exploring deer impact on soil ecosystems.

KEARNEY TEAM

BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK

References