NYBG

Rooted in resilience:

Belowground Variation in the World's Premier Urban Research Forest

2024 Forest Ecosystem Monitoring Cooperative Meeting

Brad Oberle
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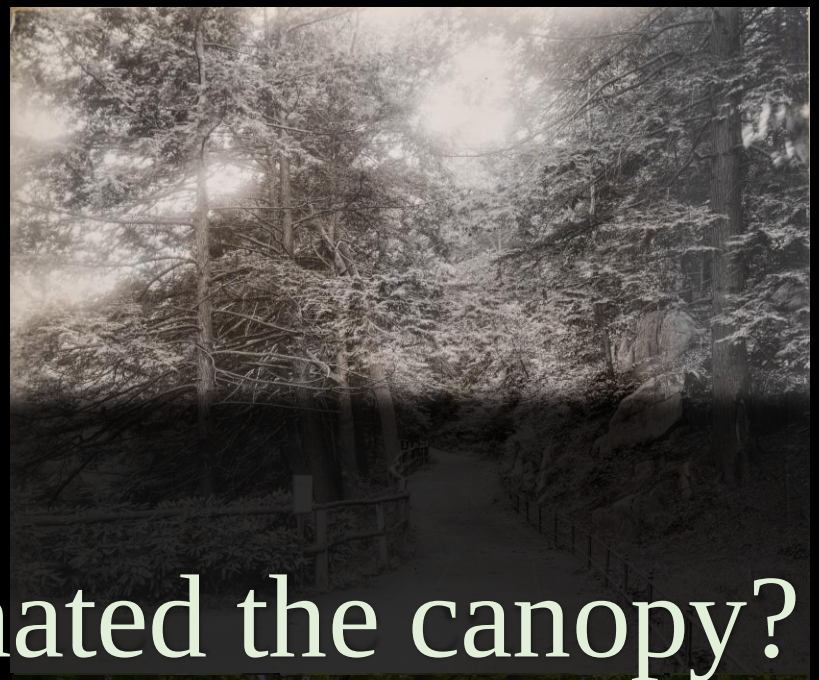
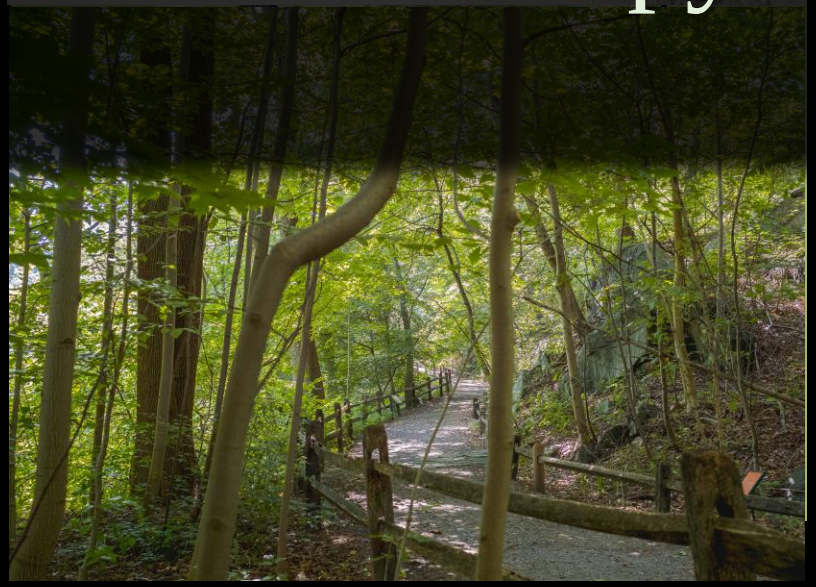
NEW YORK BOTANICAL GARDEN

NYBG Rooted in resilience:

New York Botanical Garden	• 250 acre National Historic Landmark • Bronx Park, Bronx, NY
Thain Family Forest (Hemlock Grove)	• Largest uncut old growth in NYC • 50 acres / 20 ha • Shallow, rocky, hydrophobic soils • 1.5 miles active trails
Severe Weather (1876-2016)	• 27 hurricanes • 9 nor'easters • 9 tropical storms • 10 tornados
Significant Pests/Pathogens	• Chestnut blight (1904) • Dutch elm disease (1930s) • Dogwood anthracnose (1978) • Hemlock wooly adelgid (1985) • Emerald ash borer (2009) • Beech Leaf Disease (2023)



Has 125 years of stress decimated the canopy?



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Little change in canopy tree size or density

Table I. Mean basal area (m^2h^{-1}), mean diameter (cm) and mean density (trees h^{-1}) from 1937 – 2021

(Nagele et al 2024 https://doi.org/10.1093/jofore/fvad057)

Year	Plots	Forest canopy structure (DBH ≥ 15 cm)				Forest-wide structure (DBH ≥ 2.54 cm)			
		Trees	Basal area (se)	DBH (se)	Density (se)	Trees	Basal area (se)	DBH (se)	Density (se)
1937	113	194	22.38 (2.08)[a]	32.29 (2.04)[a]	171.68 (12.91)[a]				
1985	113	252	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	789.38 (44.24)[a]
2002	113	241	23.70 (1.76)[a]	33.42 (1.59)[a]	213.27 (12.67)[a]				
2006	113	220	25.69 (2.56)[a]	33.07 (1.74)[a]	194.69 (12.05)[a]	793	27.55 (2.55)[a]	16.75 (0.97)[a]	701.77 (38.89)[a]
2011	113	194	23.62 (2.38)[a]	31.79 (2.01)[a]	171.68 (11.42)[a]	891	25.20 (2.37)[a]	14.27 (0.88)[ab]	788.50 (38.72)[a]
2016	113	199	24.60 (2.16)[a]	31.94 (1.96)[a]	176.11 (12.01)[a]	1178	26.90 (2.17)[a]	12.96 (0.83)[b]	1,042.48 (58.87)[b]
2021	113	202	23.13 (2.42)[a]	31.09 (1.98)[a]	178.76 (13.27)[a]	1161	25.66 (2.42)[a]	11.75 (0.59)[b]	1,027.43 (51.31)[b]

Are invasive trees taking over?

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High sapling recruitment

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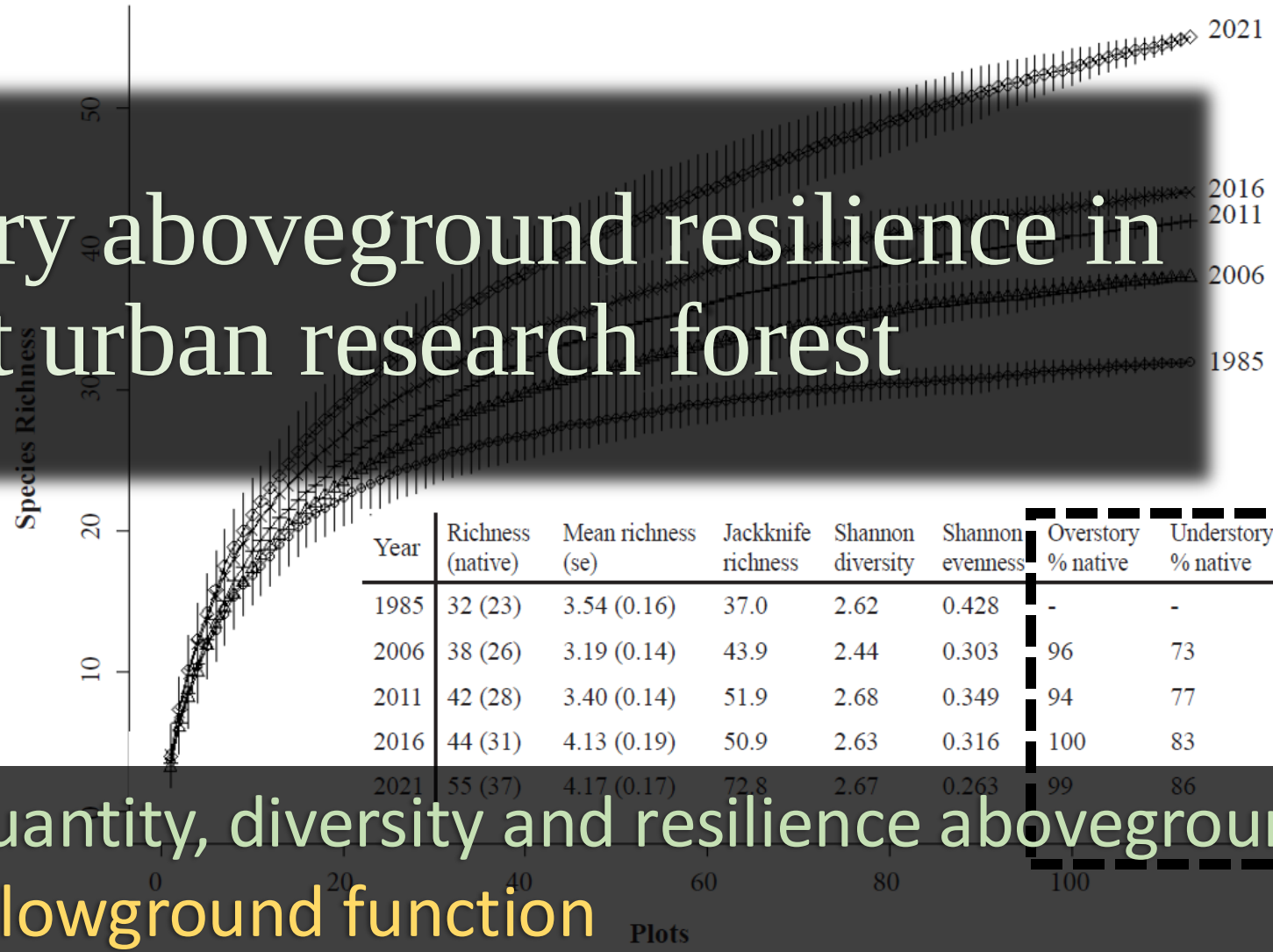
Species diversity (≥ 2.54 cm DBH)
(Nagele et al 2024 https://doi.org/10.1093/jofore/fvad057)



Year	Richness (native)	Mean richness (se)	Jackknife richness	Shannon diversity	Shannon evenness	Overstory % native	Understory % native
1985	32 (23)	3.54 (0.16)	37.0	2.62	0.428	-	-
2006	38 (26)	3.19 (0.14)	43.9	2.44	0.303	96	73
2011	42 (28)	3.40 (0.14)	51.9	2.68	0.349	94	77
2016	44 (31)	4.13 (0.19)	50.9	2.63	0.316	100	83
2021	55 (37)	4.17 (0.17)	72.8	2.67	0.263	99	86

Extraordinary aboveground resilience in oldest urban research forest

HYPOTHESIS: increasing quantity, diversity and resilience aboveground improves belowground function

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Rooted in resilience: Belowground Variation in the World's Premier Urban Research Forest

- Objective 1: tests relationships between aboveground dynamics and soil carbon variation
- Objective 2: establish a continuous record of forest-water relations
- Objective 3: connect long-term changes in soil health to urban public health

HYPOTHESIS: increasing quantity, diversity and resilience aboveground improves belowground function

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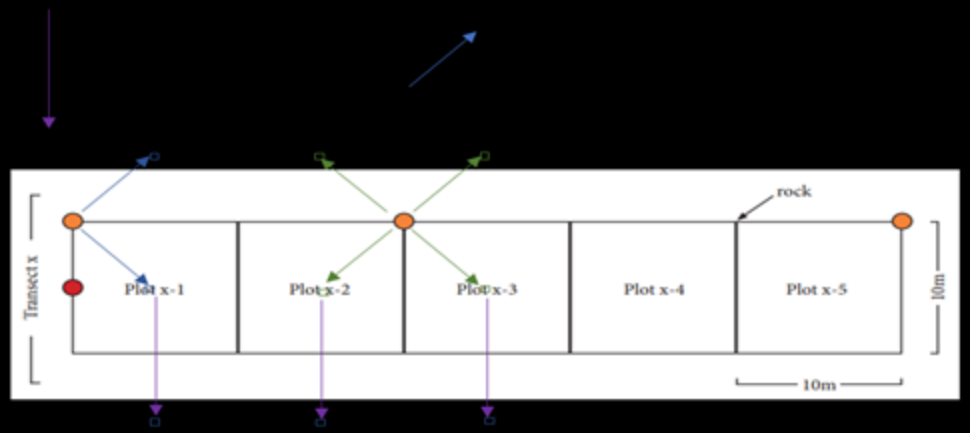
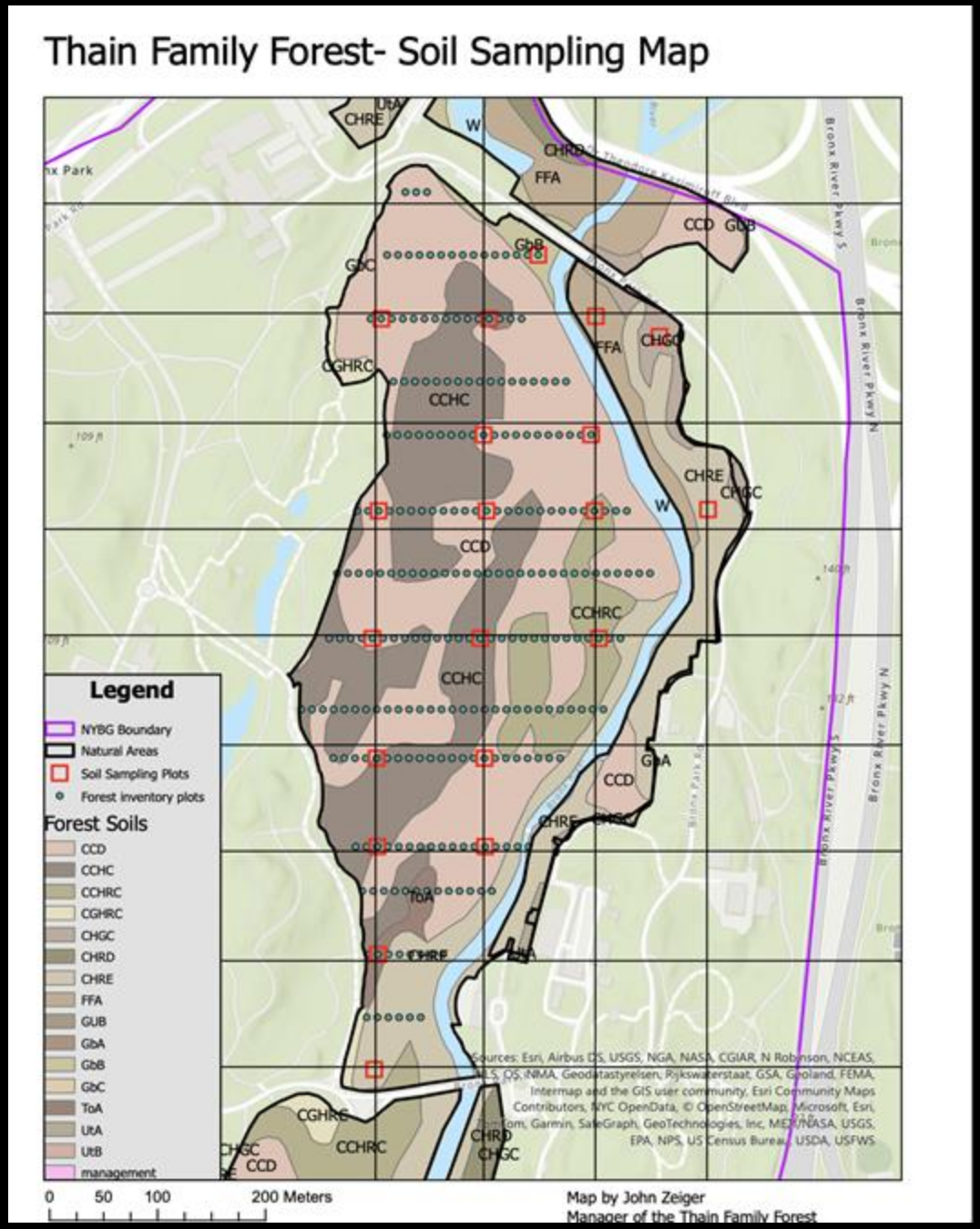
NEW YORK BOTANICAL GARDEN

NYBG Rooted in resilience:

Enhanced Ecosystem Monitoring in New York City's Only Old Growth Forest

- Objective 1: tests relationships between aboveground dynamics and soil carbon variation
  - Modified Smithsonian ForestGEO soil C protocol
    - 20 20 x 20 m plots (1 ha^{-1}) all soil types represented
    - 48 points overlap with aboveground inventory





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- Objective 1: tests relationships between aboveground dynamics and soil carbon variation
  - Modified Smithsonian ForestGEO soil C protocol
    - 20 20 x 20 m plots (1 ha^{-1}) all soil types represented
    - 48 points overlap with aboveground inventory
    - Litter mass, sampling and earthworm presence
    - Soil Organic layer depth and vertical sampling
    - Bulk density and composition

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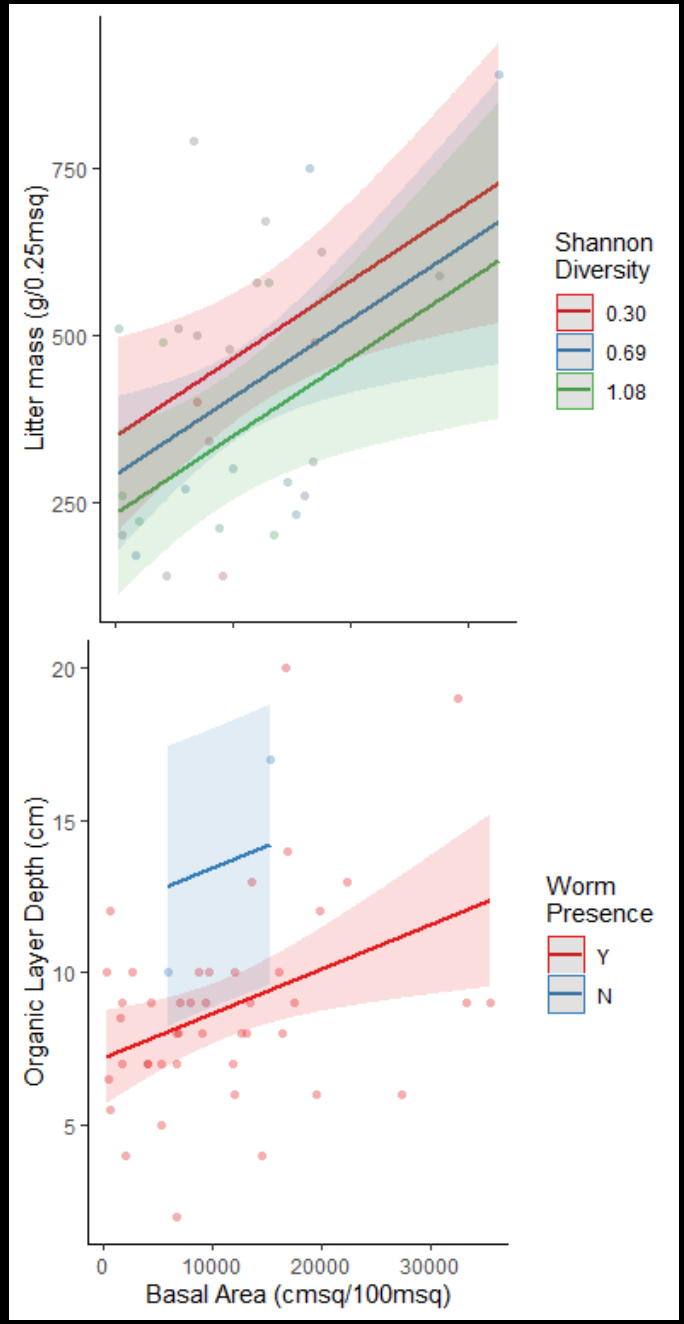
- Objective 1: tests relationships between aboveground dynamics and soil carbon variation
  - Litter mass increases with basal area but decreases with canopy diversity
    - Stepwise AIC $R^2 = 0.26$, $p = 0.006$
  - Soil organic layer increases with basal area but decreases where worms are present
    - Stepwise AIC $R^2 = 0.23$, $p = 0.009$

HYPOTHESIS: increasing quantity, diversity and resilience aboveground improves belowground function



Worms present in 173 / 179 sample locations

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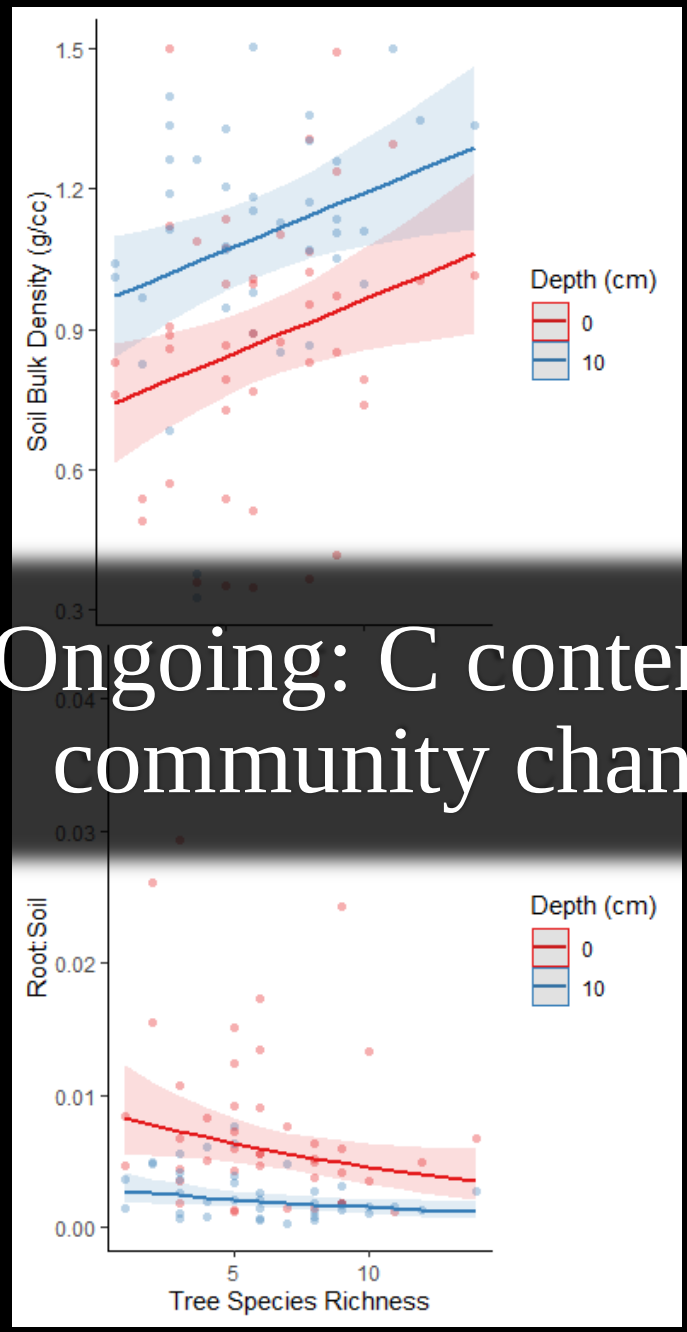
- Objective 1: tests relationships between aboveground dynamics and soil carbon variation
  - Soil bulk density increases with depth and with canopy tree species richness
    - Stepwise AIC $R^2 = 0.17$, $p < 0.001$
  - Root : soil ratio decreases with depth and with canopy tree species richness
    - Stepwise AIC $R^2 = 0.33$, $p < 0.001$

HYPOTHESIS: increasing quantity, diversity and resilience aboveground improves belowground function



50% variance within plots
30% between plots

Ongoing: C content & community change

Root : Soil also increases with moisture content

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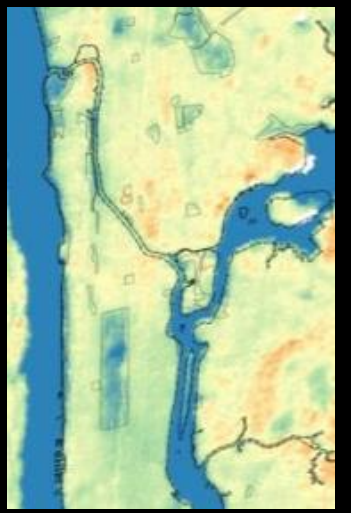
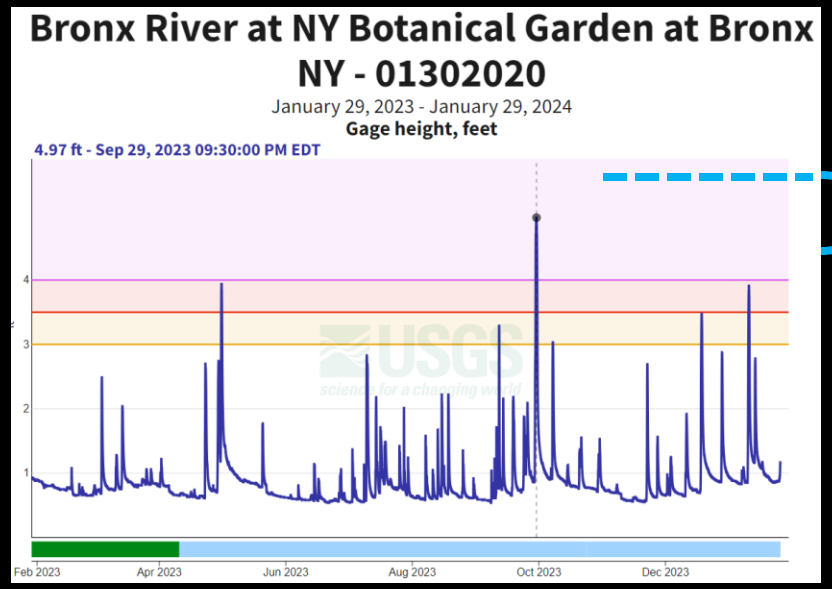


PI: Dr. Nick Steiner
City College of New York

Fine-resolution characterization of water stress in New York City urban forests with ECOSTRESS

- Objective 2: establish a continuous record of forest-water relations
  - Part of urban forest that kept 800 Statue of Liberties (25 ha^3) worth of runoff out of the river in 2012 (Nowack et al. 2018)
- What happens to soil during such a flood?



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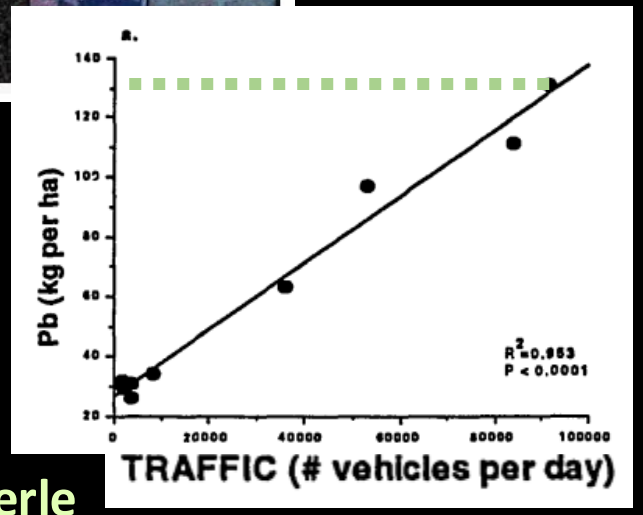
Dr. S. Perl Egendorf
Pace University

Enhanced Ecosystem Monitoring in New York City's Only Old Growth Forest

- Objective 3: connect long-term changes in soil health to urban public health
  - 1993 Foundational study of urban soil lead contamination
    - Thain Forest Soils ¼ EPA action limit (Cars)
    - How and where did lead move in 30 years?
    - Will removing the Bronx river dam remobilize pollution?
- What happens to soil during such a flood?



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THANK YOU!

Funding

FEMC

Taft

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