Urbanization effects on nitrogen cycling and plant productivity

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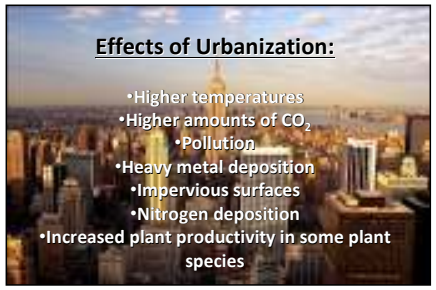
Introduction

Urban areas are rapidly increasing due to growing populations and an increasing dependence on city-based economies. There is currently more green-space in urban areas than there is in national parks.



Objectives

1. Do soil N pools vary along an urbanization gradient?
2. Does red oak (*Quercus rubra*) seedling growth differ among soils collected from sites on an urbanization gradient?
   - Do trees grown in the same environment and from the same seed bank differ in growth due only to differences in soil?
3. Does soil enzyme function vary with urbanization?
   - Phenol oxidase
   - *B*- 1, 4- N- acytylglucoseaminadase
   - Acid phosphatase
   - Glycine aminopeptidase

Methods

Field Study

- Soil NH_4^+ and NO_3^- concentrations were measured using an autoanalyzer following extraction with 1 M KCl
- Total soil N was determined using a CHN analyzer
- Soils were assayed within 48 h of sample collection for activity of extracellular enzymes according to Saiya- Cork *et al.* (2002)

Common Garden Study

- Bulk soil was collected from each site
- Red oak seedlings from a common seed bank were planted in the soil
- The seedlings were grown in a large-herbivore exclosure at the Louis Calder Center, Fordham's biological field station in Armonk, N.Y.

Study Sites

Two proxies for urbanization were used in this study:

POPULATION DENSITY

Figure 1. Variation in population density in New York State (main map) and in the sampling area (expanded view)

DISTANCE FROM URBAN CENTER

10. Housatonic State Forest, CT
9. Macedonia Brook , CT
8. Black Rock Forest. NY
7. Ward Pound Ridge. NY
6. Louis Calder Station. NY
5. Saxon Woods. NY
4. Tibbetts Brook Park, NY
3. The New York Botanical Garden, NY
2. Prospect Park, NY
1. Central Park, NY

Figure 2. Map of sites (marked by blue balloons) in sampling area and list of sites in order of increasing distance from Central Park.

Results

Field Study

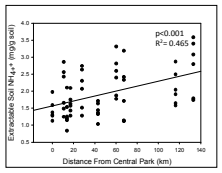


Figure 1. Linear regression of extractable soil NH_4^+ versus distance from Central Park.

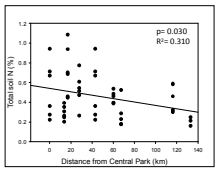


Figure 1. Linear regression of total N (%) versus distance from Central Park.

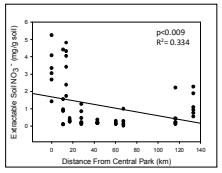


Figure 2. Linear regression of extractable NO_3^- versus distance from Central Park.

Common Garden Study

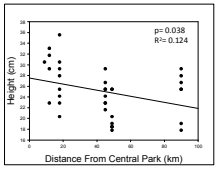


Figure 4. Linear regression of height of red oak seedlings after 7 weeks of growth versus distance from Central Park.

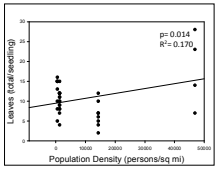


Figure 5. Linear regression of leaves on red oak seedlings after 7 weeks of growth versus population density

Conclusions

Field Study

- Soil nitrogen concentration decreased with increasing distance from Central Park (P = 0.030)
  - Extractable nitrate concentration significantly decreased with increasing distance from Central Park (P = 0.009)
  - Extractable ammonium concentration significantly decreased with increasing distance from Central Park (P > 0.001)
  - Soil pH significantly decreased with increasing distance from Central Park (P = 0.036)
  - Glycine aminopeptidase significantly increased with increasing distance from Central Park (P > 0.001)
  - Phenol oxidase , β - 1, 4- N- acytylglucoseaminadase, and acid phosphatase activity did not vary with distance from Central Park or population density

Common Garden Study

- Soils collected closer to Central Park were associated with increased growth of red oak seedlings. The increase in height was associated with both increasing population density and decreasing distance from Central Park (P = 0.045 and P = 0.014, respectively). Number of leaves on red oak seedlings significantly increased with increasing population density (P = 0.038)
  - These data suggest that belowground factors may contribute to increased productivity in this study

Future Directions

- Expand duration of the study in order to identify variation in soil enzyme function in response to seasonal changes
- Perform N root uptake bioassays on roots collected along the urbanization gradient
- Perform soil enzyme and nutrient assays in a common garden study investigating red oak seedling growth in soil collected along an urbanization gradient

Acknowledgements

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