Valuing Ecosystem Services and Disservices Across Heterogeneous Green Spaces

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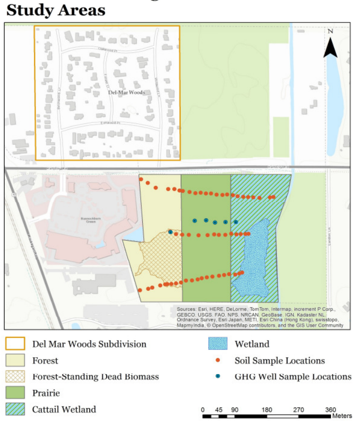
Introduction

This study investigates small-scale variability in ecosystem services and disservices that is important for sustainable planning in urban areas (including suburbs surrounding the urban core). We quantified and valued natural capital (tree and soil carbon stocks) ecosystem services (annual tree carbon sequestration and pollutant uptake, and stormwater runoff reduction) and disservices (greenhouse gas emissions and soil soluble reactive phosphorus). Our results have implications for urban planning. Adding or improving ecosystem service provision on small (private or public) urban or suburban lots may benefit from careful consideration of small-scale variability.

Study Site

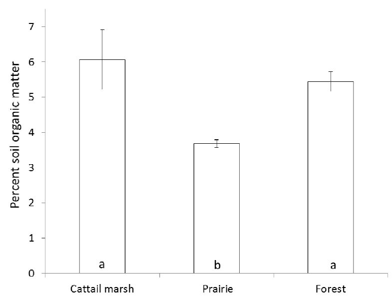
Prairie Wolf Slough and Del Mar Woods Study Areas



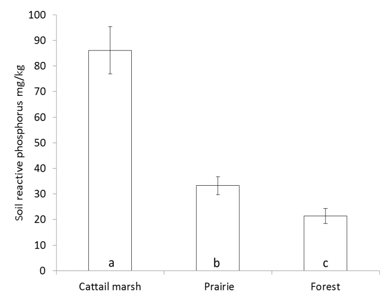
This map represents the approximately 30-hectare study site. The area includes 55% subdivision (residential), 13% wetland (cattail marsh), 13% prairie, and 16% forest green space. The East and West transects were used to sample tree carbon stocks in trees in the forested area, and soil carbon in the forest, prairie, and cattail marsh. Greenhouse gas (GHG) flux was measured in (from W-E) forest, prairie, wet prairie, and cattail marsh. GHG Well Sample Locations are indicated in blue.

Results

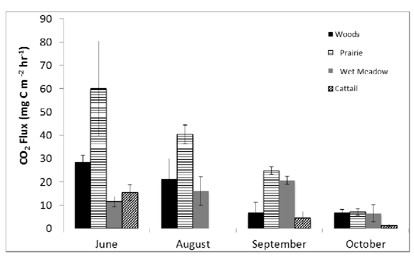
We found similar soil organic carbon across green space types, but spatial heterogeneity in other ecosystem services and disservices. The value of forest tree carbon stock was estimated at approximately $10,000 per hectare. Tree carbon sequestration, and pollutant uptake added benefits of $1,000+ per hectare per year. Annual per hectare benefits from tree carbon stock and ecosystem services in the subdivision were each 63% of forest values. Total annual GHG emissions had significant spatial and temporal variation. Soil soluble reactive phosphorus was significantly higher in the wetland than in forest and prairie.



Percent Soil organic matter by habitat: If the letter in one green space type differs from that of another green space type that indicates a significant difference in terms of percent soil organic matter.



Soil soluble reactive phosphorus by habitat: If the letter in one green space type differs from that of another green space type that indicates a significant difference in terms of soil soluble reactive phosphorus.



Analysis of Variance revealed that CO_2 flux varied significantly among months (F= 12.17, p= 3.20e-05) and by green space (F= 12.66, p = 2.36e-05) in 2013. Note that no GHG samples were collected from the cattail marsh in August due to chambers being vandalized.

Green space type	Tonnes of Carbon per hectare	Tonnes of CO_2 per hectare	Value of carbon stock at US$40.03 per tonne CO_2
Forest	62	228	$9,126.84
Prairie	54	198	$7,925.94
Cattail marsh	60	220	$8,806.60

Soil organic carbon per hectare (15 cm depth) for all green space types and accompanying per hectare valuation at different discount rates. Valuation was calculated using the social cost of carbon of US$40.03 to match valuations from i-Tree.

Methods

- Used a field inventory and the i-Tree canopy model to calculate total tree carbon stock.
- Benefits from carbon storage and pollutant uptake (ex. annual CO, NO_2, O_3 removal) were valued within i-Tree using the U.S. EPA's Environmental Benefits Mapping and Analysis.
- Carbon stock was valued by multiplying carbon stock by $40.03/tonne of CO_2 based on the estimated marginal costs of carbon dioxide emissions.
- Analyzed soil samples for percent soil organic matter using loss on ignition. Used bulk density to calculate soil organic carbon.
- Calculated soil soluble reactive phosphorus.
- Measured CO_2, CH_4, and N_2O fluxes four times in 2013 (June, August, September, October) across a hydrological gradient that encompassed four green space types using vented, non-flow through chambers.
- Used ANOVA to test for differences.

Discussion

- Soil carbon stocks were not significantly different between green space types
  - highest in the forest
  - indicates the value of soil carbon even in human-modified areas.
- Tree carbon stocks, sequestration, and pollutant removal varied spatially with tree cover, but were high in human-modified areas: approximately 63% of the neighboring forest.
- GHG flux from soil had significant spatial and temporal variation as did phosphorus (with higher SRP in the wetland).
- Incorporating knowledge of small-scale variability in ecosystem services and disservices on parcel-size lots (private or public) may improve sustainable planning in urban areas.

Reference

Klimas, C.A., Williams, A. , Hoff, M.., Thompson, J. , Lawrence, B., Montgomery, J. 2016. Valuing ecosystem services and disservices across heterogeneous urban green spaces. Sustainability.
file:///C:/Users/cklimas/Downloads/sustainability-08-00853.pdf