Quantifying Biodiversity of Urban Cemeteries in Philadelphia, PA, USA

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Background

- Cemeteries are often an overlooked part of urban green space but provide habitat for rare species and have been found to be beneficial for ecosystem function (Kjøller 2012; Buchholz et al. 2016; Kowarik et al. 2016; Tryanowski et a. 2017; Löki et al. 2019; Löki et al. 2020)
- Land management strategies and intensity are likely impacting the composition of biodiversity on urban cemeteries (Buchholz et al. 2016; Kowarik et al. 2016; Holden and McDonald-Madden 2017)
- The study in this poster is part of a larger doctoral dissertation project on biodiversity and human use of cemeteries as urban green space in Philadelphia, PA

Research Questions

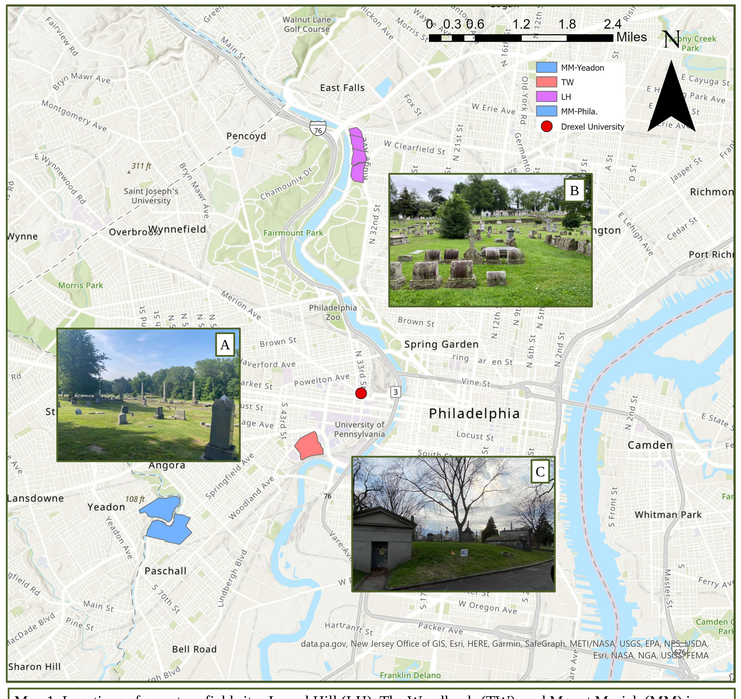
- What is the species richness of urban cemeteries?
  - What are the proportions of native to non-native species?
  - How does biodiversity vary between sites?

Field Sites

- We sampled three urban rural-style [garden-style] cemeteries in Philadelphia, PA
- Sampling stations were established at each cemetery site based on site size and homogeny of habitat types as determined by Global Moran's I Analysis in ESRI ArcGIS.
  - Global Moran's I is a tool that measures spatial autocorrelation based on feature location and values simultaneously – this allows for comparison of land use type at a site to determine whether habitat distribution is clustered, disperse, or random.
- Each cemetery has varying levels of management intensity (e.g., mowing frequency, tree maintenance, etc.) due to finances, strategic plants, and land topography and use

Site (Founding Year)	Areal Size (acres)	% Tree	% Grass	% Water	% Bare Earth	% Paved	% Buildings	Number of Sampling Stations
LH (1836)	178	25%	64%	0%	0%	10%	<1%	3
TW (1841)	54	44%	47%	0%	<1%	8%	<1%	6
MM-PHL (1855)	100	34%	58%	1%	0%	<1%	7%	6
MM-YEA (1855)	100	21%	78%	<1%	0%	<1%	<1%	3

Table 1. Categorized land use type for each field site. The majority of land use or space at each site is green (i.e., trees, grass, shrubs, etc.), however for most sites most of the green space at each site is made up of grass.



Map 1. Locations of cemetery field sites Laurel Hill (LH), The Woodlands (TW), and Mount Moriah (MM) in relation to Drexel University. Pictures of each site overlaid the map: (A) Mount Moriah Cemetery & Arboretum, (B) Laurel Hill Cemetery, and (C) The Woodlands. These rural-style cemeteries were founded in the early to mid-1800s, and are all founded in the same garden-style or rural-style cemeteries of the time. Laurel Hill is the second oldest and major rural cemetery in the United States. These cemeteries are all managed by nonprofits and are major urban green spaces in their communities.

Methods

- Taxonomic surveys conducted in September and October 2021 for a period of 2 hours per sampling station
  - Sampling stations were a minimum of 75 meters apart
    - Due to the level of noise in the city, the radius between point count locations was 75 meters which is a departure from typical minimum distance between point count sites of 200 meters
- Birds: 10-minute point counts with 5-minute acclimation period
- Vegetation: five 1x1-meter plots surveyed randomly throughout sampling stations
- Flying arthropods: set up during each survey period for 2 hours
- Ground-dwelling arthropods: pitfall traps were set up for 48-hour periods
- Terrestrial mollusks: targeted hand searching; beer traps set up for 72-hour periods
- Analysis: Shannon-Weiner Diversity Index (SDI), Evenness, and Jaccard's Similarity Index (JSI)

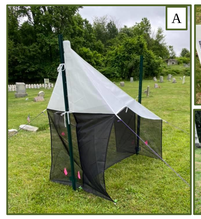


Figure 2. Examples of the taxonomic survey methods pictured here. Malaise traps were used to assess flying arthropods (A). Pitfall traps were a preliminary method for assessing ground-dwelling arthropods, but turned out not to be ideal for site assessment due to various constraints (B), however beer-filled pitfall traps (C) were used to assess terrestrial mollusks when targeted hand searching was yielding no results. A wire cage was put over the traps to prevent bycatch. Field assistants conducting a vegetation survey at The Woodlands in September 2021 (D).

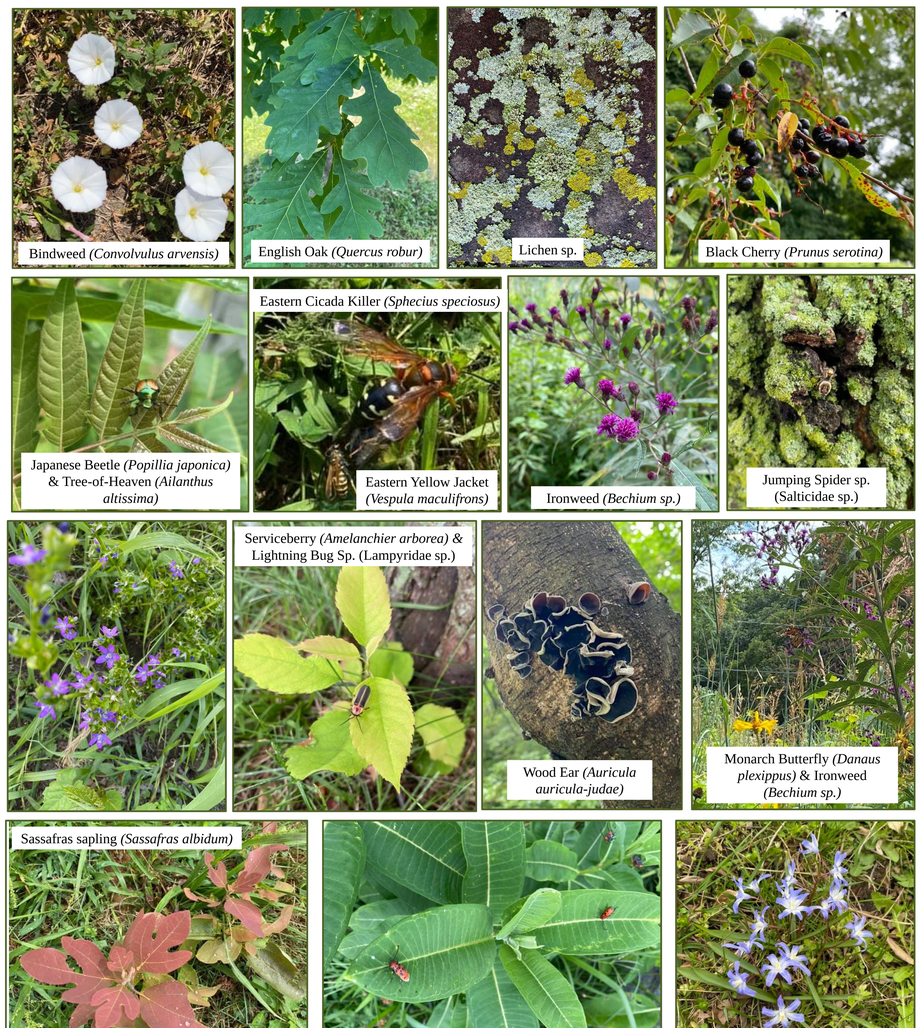


Figure 3. Examples of species observed at the three field sites Laurel Hill, The Woodlands, and Mount Moriah.

RESULTS

- Across all sites: 111 plant species, 41 bird species, 3 terrestrial mollusk species, and 5 arthropod orders (Table 2)
  - Same 3 species of non-native birds observed at all sites, but otherwise bird species observed were native to the region
  - TW and MM had higher numbers of species of non-tree vegetation compared to MM (Table 2)
  - MM had the highest species count for all taxa and for flying arthropods (Table 3)
- All sites had similar proportions of native to non-native plants with majority of plant type being herbaceous plants and grasses, and non-native species (Table 4)
- Results for Shannon-Weiner Diversity Index, Evenness, and Jaccard's Similarity Index are summarized in Tables 5-7
  - Sites had moderate to high diversity but low evenness
  - Similarity of data between sites was low

Site	Plant Spp. Count	Bird Spp. Count	Mollusk Spp. Count	Insect Order Count	Species Totals
LH	32	10	3	4	49
TW	66	11	2	4	83
MM	57	27	0	5	89

Table 2. Species and Order count for all field sites from surveys conducted September and October 2021.

Site	Diptera	Hymenoptera	Hemiptera	Coleoptera	Arachnid
LH	52	9	1	1	0
TW	58	17	0	1	0
MM	150	38	4	2	2

Table 3. Number of individual specimens collected at each site identified to order or class.

LH Plant Type	Species Count	Proportion
Native	4	13%
Non-Native	18	56%
Unknown	10	31%
TW Plant Type	**Species Count**	**Proportion**
Native	14	22%
Non-Native	28	42%
Unknown	24	36%
MM Plant Type	**Species Count**	**Proportion**
Native	12	21%
Non-Native	26	46%
Unknown	19	33%

Table 4. Species count and proportion of plant type at each field site. All sites had more non-native than native plants. TW and MM had similar proportions of native and non-native plants. Laurel Hill had least amount of native herbaceous plants. Around 33% of plant species were determined as unknown and could not be determined native or non-native. Some plants were only identified to genus due to lack of plant structures needed for positive identification.

Site	H' value	Evenness
LH	0.98	0.18
TW	0.69	0.18
MM	0.81	0

Table 5. Shannon-Weiner Diversity Index (H') and Evenness were calculated to evaluate total diversity at all surveyed sites.

Site	H' value	Evenness
LH	0.57	0.14
TW	0.61	0.13
MM	0.75	0.14

Table 6. Shannon-Weiner Diversity Index (H') and Evenness were calculated to evaluate arthropod diversity at all surveyed sites.

Site	LH	TW	MM
LH	0	--	--
TW	0.04	0	--
MM	0.039	0.039	0

Table 7. Jaccard's Similar Index were calculated to evaluate similarity of data between sites.

Discussion & Future Directions

- Results indicate that study sites have low diversity (SDI value) and low evenness (relative abundance)
- JSI suggests that although species documented may have been found at more than one site, overall site species composition are not similar when compared to each other
- SDI, evenness, and JSI results and higher numbers of non-native species are indicative of urban environments which are subject to biotic homogenization and low diversity
- Analyzing tree composition at each site will provide further insight into biodiversity and proportion of native to non-native plant species
  - Inventorying trees at Mount Moriah is in progress in order to compare tree species composition across sites
- Future efforts will elucidate relationships between cemetery biodiversity and human utilization and perception of these urban green spaces

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