Plant and Insect Biodiversity on NYC Green Roofs: Initial Patterns of Colonization, Survivorship, and Function

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Columbia University
How do green roof biotic communities change in time and space?

What controls the structure and function of biotic communities on green roofs?

How will design decisions influence those patterns and functions?
Environmental conditions on a green roof

• Lots of sunlight
• High daytime temperatures in summer
• Wide temperature swings
• Exposure to wind
• Frequent drought conditions
• Thin soil
Green Roof Plants

• The defining feature of green roofs is the presence of living plants

• The primary functions of the plants are to affect temperature and water, to stabilize the substrate, and to look good

• Most large green roofs use Sedum species, which grow well under rooftop conditions
Sedum

- Root easily and spread quickly
- Survive droughts and other harsh conditions
- Remain evergreen as succulent perennials
- Create simple communities
- Provide limited resources to other organisms
Native Vegetation in NYC and the Mid-Atlantic

- Mostly deciduous forest, with surrounding tidal marshes
- Native grasslands present in areas with limited water, and soil depth, or frequent disturbance regimes
- Grasslands have high plant diversity and provide habitat for many uncommon birds and insects
Model Communities: Local Grasslands
Rocky Summit Grassland

Throughout Hudson Highlands

Rocky summits and exposed rocky slopes

Bear Mountain State Park, Black Rock Forest

S3 - Edinger et al. 2002

Image: TNC
Rocky Summit Grassland

Deschampsia

Danthonia

Carex
Rocky Summit Grassland

Pycnanthemum

Lespedeza

Cunila

Solidago

Lysimachia
Hempstead Plains

Nassau County, central Long Island

Historically 60,000 acres (24,300 ha)

<< 1% remains in historic vegetation

Image: Friends of Hempstead Plains

G1, S1 Edinger et al. 2002
Hempstead Plains

Schizachyrium

Sorghastrum

Panicum
Hempstead Plains

**Eupatorium**

**Solidago**

**Asclepias**

**Baptisia**

**Rubus**
Fieldston Middle School

8 plots - 3 m x 3m
Installed 2007-2008
Green Roof Education Programs

- Inquiry-based and place-based education
- Significant quantitative gains in content knowledge
- Qualitative themes indicative of improved attitudes towards science
- Shift in attitudes about nature and sustainability
Fieldston Lower Roof - September 2011
4 years since initial planting
Development of plant and insect communities

- Comparison between Fieldston (4 years old) and Barnard (1 year old)
- Plant survivorship patterns in first year are similar
- Insect diversity was lower on the older roof
  - Counter to predictions
- Pitfall traps yielded more captures than sweep nets
Effects of vegetation on arthropod communities

- 18 roofs spanning 3 vegetation types in all 5 boroughs
- Pollinator visitation, sweep nets and pan traps
# Orders Collected in Pan Traps

<table>
<thead>
<tr>
<th>Order</th>
<th>Total</th>
<th>% of Total</th>
<th>Frequency (1-18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diptera</td>
<td>2170</td>
<td>35.5</td>
<td>18</td>
</tr>
<tr>
<td>Collembola¹</td>
<td>1396</td>
<td>22.9</td>
<td>16</td>
</tr>
<tr>
<td>Hymenoptera</td>
<td>910</td>
<td>14.9</td>
<td>18</td>
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<tr>
<td>Hemiptera</td>
<td>868</td>
<td>14.2</td>
<td>17</td>
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<tr>
<td>Thysanoptera</td>
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<td>4.7</td>
<td>18</td>
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<tr>
<td>Lepidoptera²</td>
<td>141</td>
<td>2.3</td>
<td>14</td>
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<tr>
<td>Araneae²</td>
<td>118</td>
<td>1.9</td>
<td>13</td>
</tr>
<tr>
<td>Coleoptera</td>
<td>107</td>
<td>1.8</td>
<td>16</td>
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<tr>
<td>Acari²</td>
<td>89</td>
<td>1.5</td>
<td>4</td>
</tr>
<tr>
<td>Opiliones²</td>
<td>10</td>
<td>0.2</td>
<td>1</td>
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<tr>
<td>Psocoptera</td>
<td>7</td>
<td>0.1</td>
<td>5</td>
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<tr>
<td>Orthoptera</td>
<td>2</td>
<td>0.0</td>
<td>2</td>
</tr>
<tr>
<td>Neuroptera</td>
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<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6107</strong></td>
<td><strong>100.0</strong></td>
<td></td>
</tr>
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</table>

## Mixed Sedum Unplanted

**Diversity Score**

<table>
<thead>
<tr>
<th></th>
<th>Mixed</th>
<th>Sedum</th>
<th>Unplanted</th>
</tr>
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<tbody>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
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<td></td>
</tr>
<tr>
<td>60</td>
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<tr>
<td>80</td>
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### Kruskal Wallis

X²=5.19, 2 d.f., p=0.07

**Abundance per pan trap**

- **Diptera: Sciaridae** Common in Sedum
- **Diptera: Dolichopodidae** Common in Mixed
- **Collembola: Sminthuridae** Common in Sedum
- **Hemiptera: Aphididae** Common in Unplanted
- **Collembola: Isotomidae** Common in Mixed
Experimental Green Roofs on Recreation Centers

Lost Battalion Hall
Recreation Center, Queens
10 roofs across all 5 boroughs
12 plots per roof, 4 m x 2m
6 plots 10 cm depth, 6 plots 15 cm depth
Each plot planted with two vegetation subplots

Hempstead Plains:

Schizachyrium scoparium
Panicum virgatum
Sorghastrum nutans
Baptisia tinctoria
Solidago nemoralis
Asclepias tuberosa
Eupatorium hyssopifolium
Symphyotrichum laeve

Rocky summit:

Danthonia spicata
Deschampsia flexuosa
Dichanthelium clandestinum
Lespedeza capitata
Ionactis linariifolius
Pycnanthemum tenuifolium
Solidago odora
Rudbeckia hirta
Spontaneous vegetation on green roofs

- How do roofs with identical starting conditions vary in the development of vegetation?
- What plants colonize green roofs?

Biomass of colonists

Seed traps

Landscape analysis

Spontaneous vegetation on green roofs

• How do roofs with identical starting conditions vary in the development of vegetation?
• What plants colonize green roofs?

Biomass of colonists

Seed traps

Landscape analysis
• 30 plant species colonized unplanted media before installation

• Numerical dominance by *Amaranthus blitoides* and *Poa annua*

• Greater biomass of weeds in 15 cm deep plots (92 ±110 g/m²) than in 10 cm plots (32 ± 57 g/m²)
Assembly of insect communities across NYC

- How does insect community assembly vary across roofs with identical starting conditions?
- What are the dominant pollinator groups on green roofs?
- How are Syrphid flies distributed across NYC?

[Images of a person on a green roof, a Syrphid fly, and a honey bee]

Jeremy Law - E3B

Diptera: Syrphidae Hoverfly

Hymenoptera: Apidae Honey bee
Hydrologic Functions of Green Roof Vegetation

- Estimating evapotranspiration through water loss
- Measuring stomatal conductance directly

Moisture Draw–Down by Growth Form

Trevor Granger - E3B
Cumulative Water Loss

<table>
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<tr>
<th>Depth: 15cm</th>
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<tr>
<td><strong>Low Frequency</strong></td>
<td><strong>Medium Frequency</strong></td>
<td><strong>High Frequency</strong></td>
</tr>
<tr>
<td>Ctrl</td>
<td>Da</td>
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Cumulative water loss (kg)

Species: Ctrl, Da, Di, Sor, Sy, Sed

Depth: 10cm

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## Cumulative Water Loss Scaled by Mean Leaf Area Index

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<tr>
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<td>0.010</td>
<td>0.015</td>
</tr>
<tr>
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<td>0.010</td>
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<td>0.020</td>
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<tr>
<td>Sy</td>
<td>0.015</td>
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<tr>
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Future Directions

• Evaluate a much broader range of plant species and communities for green roof applications

• Evaluate interactions between vegetation and water flux and water quality in the greenhouse, mesocosms, and extensive roofs

• Compare assembly of biotic communities as a function of starting conditions and location

• Examine “soil” development

• Evaluate role of green roofs in connecting other green spaces and supporting urban biodiversity
Thank you