Impacts of climate change on urban biodiversity

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Air polluted, **warm and dry**, high CO\(_2\)-content

Soils nutrient rich, **sealed**, compacted and **dry**

Groundwater often low, rivers channeled

Figure modified after Sukopp 1973
Urban heat island

Figure modified after Thüringer Landesanstalt für Umwelt und Geologie, www.tlug-jena.de / Heat Island Group
Changes in the composition of the flora:

- Species composition
- Functional composition
- Phylogenetic composition

Urban areas are models for future non-urban areas in a warmer climate.

Hard to disentangle effects of urban climate vs. climate change on biodiversity.
Flora of the city of Halle (Saale): 1687 to 2008 – 320 years in total

Pictures: wikipedia.de
Flora Halensis

FRIDERICI WILHELMI a LEYSER

ENUMERATIO PLANTARUM CIRCA HALAM SAXONIUM ET IN EJUS VICINIA, AE TRIUM FERE MILLIARIUM SPATIUM, SPONTE PROVENIENTUM,

Cum earum Synonymiis, locis, natalibus ubi proveniunt, & temporibus qvo florent, additis characteribus generum, fumorum atque subalternorum, & Indicii copioso, in Botanophiliorum gratiam methodice confignata, studio

CHRISTOPHORI Snauths Med. D. & Physici Patræ Ordinarii

LIPSÆ
Sumpt. Harei. FRID. LANCK I SII. Anno M DC LXXXVII.

1687

1761

Flora von Halle

mit näherer Berücksichtigung der Umgebung

von

Weissenfels, Naumburg, Freiburg, Bibra, Nebra, Querfurt, Allstedt, Artern, Eisleben, Hettstedt, Sandersleben, Aschersleben, Stassfurt, Bernburg, Köthen, Dessau, Oranienbaum, Bitterfeld und Delitzsch

von

Dr. August Gareke.

1848

1987

Aus der Sektion Blauwissenschaften
der Martin-Luther-Universität Halle-Wittenberg
Wissenschaftsbereich Geobotanik und Botanischer Garten
(Leiter des Wissenschaftsbereiches: Prof. Dr. R. Schubert)

Anthropogene Florenveränderungen in der Agrarlandschaft nördlich von Halle (Saale)
2. Folge: Arten der naturnahen Vegetation

Von Eberhard Große
Mit 22 Abbildungen
(Eingegangen am 17. März 1986)
Since the end of the 17th century, many non-native species adapted to high temperatures established in Halle.

Knapp, Kühn, Stolle, Klotz (2010) Perspectives in Plant Ecology, Evolution and Systematics 12, 235-244
Since the end of the 17th century, many non-native species adapted to dry soils established in Halle

Knapp, Kühn, Stolle, Klotz (2010) Perspectives in Plant Ecology, Evolution and Systematics 12, 235-244
Buddleja davidii Franch.
Adapted to high temperatures and relatively dry soils;
Established in Halle since the 2nd half of the 20th century

Solidago canadensis L.
Adapted to relatively high temperatures;
Established in Halle since the first half of the 20th century
Senecio inaequidens DC.
Adapted to high temperatures and dry soils;
Established in Halle since the 2nd half of the 20th century
Native species adapted to low temperatures were preferably extirpated since the end of the 17th century.

Species increasingly adapted to high temperatures

Knapp, Kühn, Stolle, Klotz (2010) Perspectives in Plant Ecology, Evolution and Systematics 12, 235-244
Native species adapted to moist soils were preferably extirpated since the end of the 17th century.
Orchis palustris Jacq.
Adapted to wet soils;
Absent from Halle since the early 19th century

Trollius europaeus L.
Adapted to low temperatures and moist soils;
Absent from Halle since the end of the 19th century

Drosera rotundifolia L.
Adapted to low temperatures and wet soils;
Absent from Halle since the end of the 20th century

Pictures: www.floraweb.de
How plants adapt to warm & dry conditions in urban areas

- Safe water by decreasing transpiration:

- e.g., with scleromorphic leaves

Knapp et al. 2008, Preslia; Picture: www.guenther-blaich.de
Avoid the hottest months:

- Be short lived: complete your life cycle in the cooler season
- Survive drought as a seed
- Flower early or late in the year

Knapp et al. 2008, Preslia; Pictures: www.floraweb.de
Phylogenetic diversity measures the evolutionary relatedness of species.
Phylogenetic distinctness of the German flora

- **Germany:** Lower phylogenetic diversity in urban than non-urban areas. (Knapp et al. 2008, Ecology Letters)
- **Minnesota/USA:** Lower phylogenetic diversity in urban yards than in natural areas. (Knapp et al. 2012, Ecology)
- This might be driven by closely related non-native species. (Cadotte et al. 2010, Diversity & Distributions 16, 892-901)
Phylogenetic Distinctness of the flora of Halle (Saale)

Decrease of phylogenetic diversity in urban areas related to temperature???

Knapp et al. in prep.
Changes in the composition of the flora:

- Species composition
- Functional composition
- Phylogenetic composition

- Urban areas are models for future non-urban areas in a warmer climate

- Hard to disentangle effects of urban climate vs. climate change on biodiversity

- Increasing temperatures
- Decreasing soil and air moisture
- Increasing CO₂ concentrations
Nature-based solutions to climate change mitigation and adaptation in urban areas

<table>
<thead>
<tr>
<th>Species</th>
<th>Functional Traits</th>
<th>Leaf Size (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acer saccharinum</em></td>
<td></td>
<td>75</td>
</tr>
<tr>
<td><em>Tilia platyphyllos</em></td>
<td></td>
<td>124 ± 8, 127</td>
</tr>
<tr>
<td><em>Platanus acerifolia</em></td>
<td></td>
<td>247 ± 7, 319</td>
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<tr>
<td><em>Aesculus hippocastanum</em></td>
<td></td>
<td>137 ± 8, 82</td>
</tr>
<tr>
<td><em>Gleditsia triacanthos</em></td>
<td></td>
<td>1.8</td>
</tr>
</tbody>
</table>

Importance of species functional traits, such as leaf size

Importance of how species are planted (e.g., in street canyons)


Leuzinger et al. (2010), Agricultural and Forest Meteorology
Thank you for attention!