

Residential Landscape Microclimates Mitigate the UHI in Cities across the US

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Background

Urban Heat Island (UHI)

- The UHI is well-documented for cities worldwide. *Urban areas retain heat compared to rural areas:*

Overall temperature \uparrow

Diurnal temperature range (DTR) \downarrow due to higher T_{min}

- Irrigation and vegetation creates localized, cool microclimates that can mitigate the UHI ("Park Cool Islands").

Ecological Homogenization of Urban America project

- Do cities across the US exhibit social and ecological 'sameness' relative to native habitats? (Fig. 1).
- Investigations occur at the **human scale** (residential & native microclimate).

Using air temperature data collected from yards and native landscapes, we address the following questions:

- What is the nature of the UHI from the perspective of the human habitat, in comparison to native habitats?
- Does the UHI contribute to urban homogenization among cities located in variable climate zones?

Methods

Microclimate sensors

- iButtons: 15 residential yards and 3 native habitats in each city
- Sensors enclosed in a gill-style radiation shield and hung at 1.5m height, 1m from structures or vegetation (Fig. 2)
- Air temperature and humidity measurements collected hourly from Aug. 2012 – Oct. 2014.

Data processing

- Urban (airport) climate data queried from the NCDC database
- All data filtered to remove days with any measured precipitation**
- Diurnal Temperature Ranges (DTR) calculated: $T_{max} - T_{min}$ daily for each sensor
- We used ANOVA to compare overall and monthly mean min and max temps, and DTR, among all three site types (residential, native, and airport) within each city.



Figure 2. iButton deployed in a gill-style radiation shield at Utery Mountain park; a native habitat site (Sonoran Desert) in Phoenix, AZ.

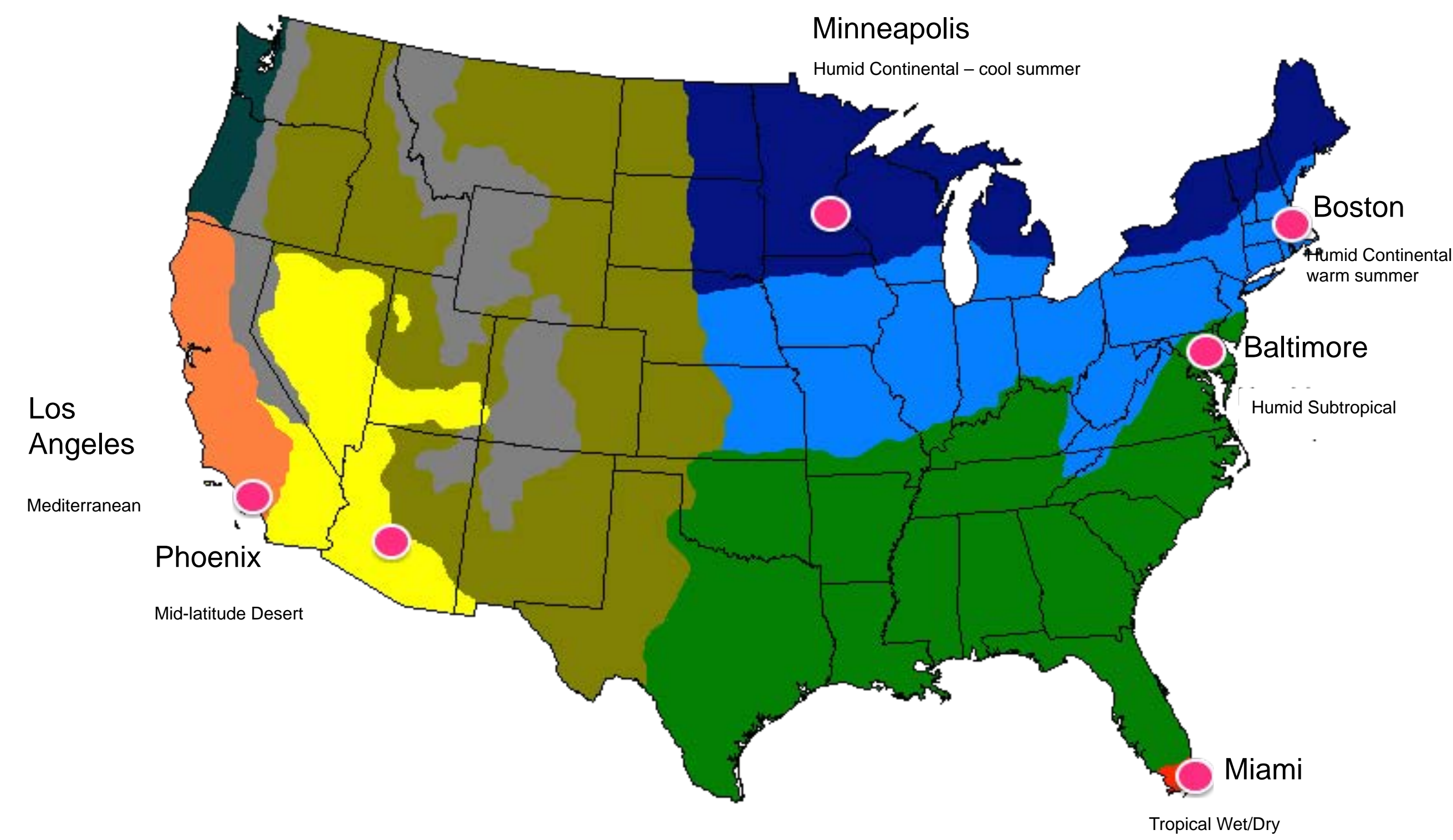


Figure 1. Urban Homogenization study cities and associated climate zones.

Results

Overall DTR trends

- DTR in Residential yards** > airports in all cities ($p < 0.001$)
- DTR in Native habitats** > airports in 5 out of 6 cities ($p < 0.001$)

Seasonal DTR patterns

- During warming and cooling months, **DTR in Residential yards** > native for **Phoenix, Los Angeles, and Miami** (Fig. 3). *Residences experience significantly lower minimum temperatures than native habitats.*
- During hot summer months, **DTR in Residential yards** > native habitats for **Miami and Baltimore** (Fig. 3). *Residences in Miami and Baltimore experience significantly higher maximum temperatures than native habitats.*
- DTR in Residential yards was not significantly greater than native habitats in **Boston** or **Minneapolis**.

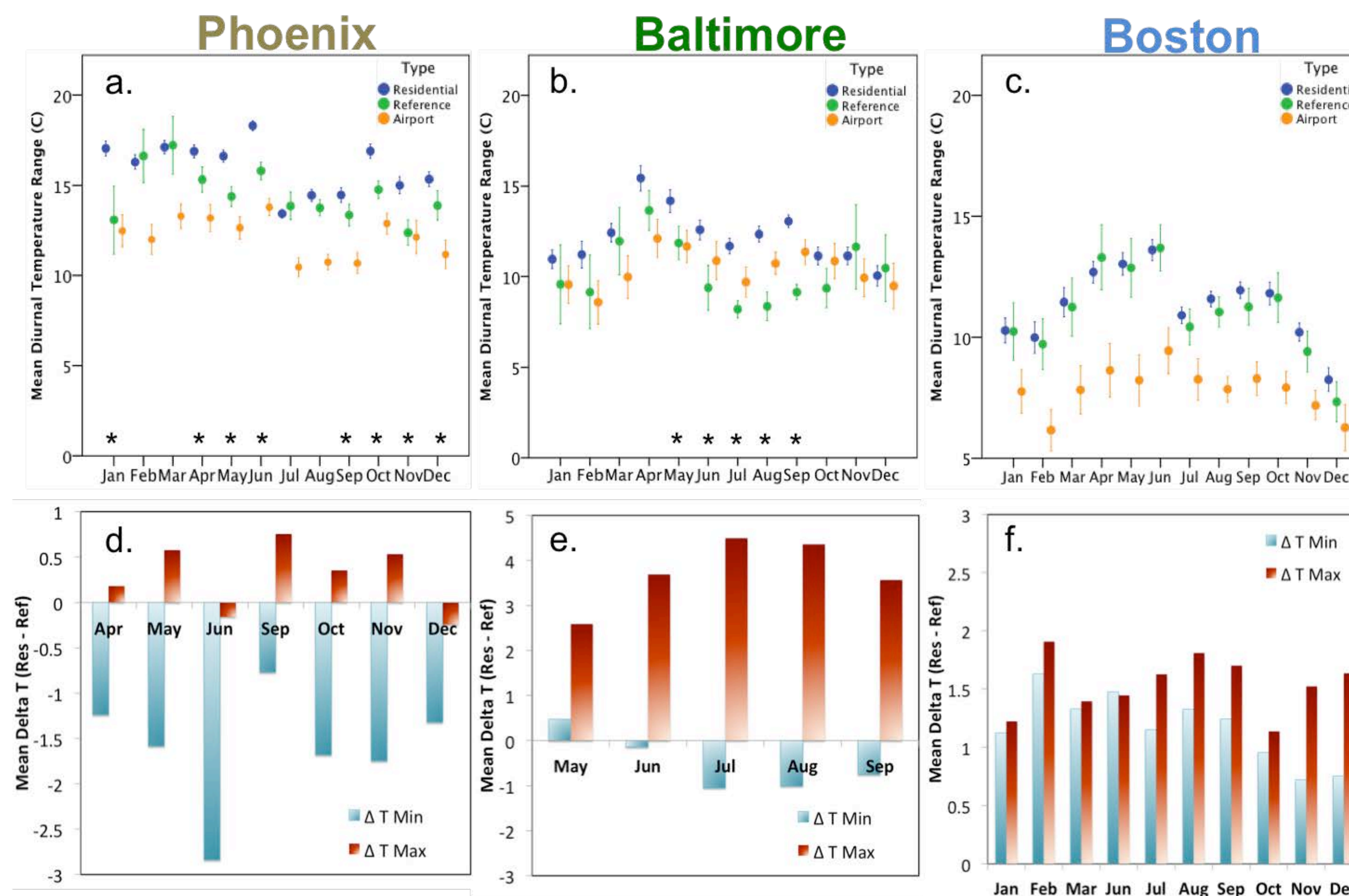


Figure 3. Monthly mean DTR for each site type in Phoenix (a), Baltimore (b) and Boston (c). Significant differences between residential and native sites are marked (*) ($p < 0.05$). Mean ΔT_{min} (Res - Ref) and ΔT_{max} (Res - Ref) are shown for Phoenix (d) and Baltimore (e) for months when residential DTR is significantly greater than reference DTR, and for all months in Boston, where residential and reference site DTR is similar.

Reversing the UHI in the human habitat

Microclimates in residential landscapes are more similar to native habitats than they are to nearby urban weather stations.

- Neighborhoods can contribute to a "Park Cool Island" (PCI) effect which has been documented for urban parks and green spaces.

Urban Homogenization?

Across the continent, residential microclimates differ from native habitats seasonally.

- Residential and native habitats are the most similar in cool, wet cities.
- Minimum temperatures influence differences in warm, dry cities, while maximum temperatures have a greater effect in warm, wet cities.

Greater daily temperature ranges in yards alleviates the effects of the UHI in cities; however, the drivers are geographically variable.