A Green Heart for Healthy Communities

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What’s In The Air?
Climate change is the greatest threat to human health.

HUMANS, YOU’RE ENDANGERED TOO.
Climate Change is Inherently Local

“Impacts are experienced differently within segments of the population and between geographic locations based on biological, social, and economic vulnerabilities as well as the nature of the climate hazard.” (Patz and Thomson, 2018)
Climate change intensifies health risks for sensitive groups.

- Children
- Older adults
- Impoverished communities
- Communities of color
- Indigenous communities
- People with a disability
- Undocumented residents
- LGBTQ+
The World Health Organization estimates that 88% of the global burden of climate change falls on children younger than 5 years old.

(Ahdoot and Pacheco 2015)
Children aren’t just little adults, they:

- Have immature and developing organ systems
- Breathe in more air and take in more water per body weight
- Are completely dependent on adults to make decisions for them
- Have unique behaviors: hand-to-mouth and crawling activities
- Can be exposed via breastmilk or the placental barrier

Image source: https://bit.ly/2Fk3uth
Climate change threatens mental wellness:

- Stress
- Anxiety
- PTSD
- Depression
- Violence
- Suicide
- Medication interaction
Climate Threats to Health and Equity

Extreme Weather
Flooding and Drought
Vectorborne Diseases
Air Quality
Extreme Heat
Extreme Weather

- Water contamination
- Property Loss
- Infrastructure Damage

- Gastrointestinal illness
- Cardiovascular disease
- Respiratory illness
- Injuries
- Stress
- Displacement
- Death
Extreme Weather

Displacement
Over 30,000 evacuated

Property Loss
At least 88 deaths

Infrastructure Damage
Loss of access to health services

Water contamination
Gastrointestinal illness and skin rash increased

Hurricane Harvey

USGCRP, 2018
Extreme Weather Adaptation

- Disseminate alerts
- Ensure evacuation access

Wu et al., 2019
Extreme Precipitation

Precipitation extremes harms **physical and mental health**, community infrastructure, and the economy.

- **FLOODING**
  - Water contamination
  - Community destruction
  - Gastrointestinal illness
  - Injury, death

- **DROUGHT**
  - Decreased crop yield
  - Wildfires
  - Malnutrition
  - Asthma, heart disease
# Extreme Precipitation - Drought

<table>
<thead>
<tr>
<th>Drought and Health Equity</th>
<th>Impoverished</th>
<th>Agricultural Workers</th>
<th>Rural Communities</th>
<th>Tribal Communities</th>
<th>Chronic Illness</th>
<th>Race and Ethnicity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Food and water insecurity</td>
<td>Economic and mental health impacts</td>
<td>Reliant on small or private drinking water systems</td>
<td>Close ties to land and some communities lack running water</td>
<td>Exacerbate kidney disease, diabetes, and hypertension</td>
<td>Heightened economic threat</td>
</tr>
</tbody>
</table>

APHA, PHI, CDPH, 2018
Extreme Precipitation

- Assess water and soil quality
- Issue water advisories

**Graduated Planning Controls**

- Critical utilities e.g., hospitals, evacuation centres
- Standard single storey houses
- Flood resistant single storey houses
- Flood resistant two-storey, high rise residential, industrial, commercial
- Agriculture, recreation, open space, some commercial

**Floodwalls:** Building a wall to keep flood water from reaching a building

**Dry floodproofing:** Making the walls of the buildings and the openings watertight

**Wet floodproofing:** Altering a building to minimize damage when flood waters enter

**Relocation:** Moving a building to high ground, above flood level

**Elevation:** Raising a building so that flood waters will go under it

**Floodproofing through recommended best practices in building code regulations**

*Hawkesbury City Council, 2012; UFCOP, 2017*
Vectorborne Disease

Climate change increases the amount and geographic distribution of disease-carrying mosquitos and ticks.

<table>
<thead>
<tr>
<th>Vectorborne diseases</th>
<th>Lyme disease</th>
<th>West Nile virus</th>
<th>Zika virus</th>
</tr>
</thead>
</table>

Vectorborne Disease

Disease cases from infected mosquitoes, ticks, and fleas have tripled in 13 years.

Figure Source: Center for Disease Control and Prevention, 2018.

Salas, Knappenberger, Hess, 2018
Vectorborne Disease Adaptation

Integrated Pest Management

**PREVENT**
the build-up of pests

**MONITOR**
environmental and health status

**INTERVENE**
when control measures are needed

Vectorborne Diseases
- Educate
- Vector control
- Eradicate vector-prone areas
Air Quality

EXPOSURES
- Air Pollution
- Extreme Heat
- Wildfire Smoke
- Allergens

HEALTH OUTCOMES
- Asthma
- Allergies
- Kidney Disease
- Mental Health
- School/Work Absences

Poor air quality exposure can harm human health and wellbeing.
Risk Factors for Cardiovascular Disease

- Traditional risk factors do not fully explain CVD
- **70-80%** of CVD could be due to environmental causes
- Temperatures influence air quality.

Bhatnagar, 2006, 2017
The Contribution of Air Pollution Versus Other Risk Factors to Global Mortality

Risk estimates provided by several cohort studies per increment of 10 μg/m³ in PM$_{2.5}$ or PM$_{10}$

CPD = cardiopulmonary disease
CVD = cardiovascular disease
IHD = ischemic heart disease
Acrolein and benzene exposures are linked with higher CVD risk.

DeJarnett et al. 2014

Abplanalp, DeJarnett, et al. 2017
Inverse Association between Spatial Variation and Residential Greenness and Volatile Organic Compound Metabolites

Yeager et al. 2018
Redlining and Air Quality

Modern air pollution disparities in historically redlined areas

Los Angeles, CA

Detroit, MI

Philadelphia, PA

Chicago, IL

202 redlining maps drawn in the 1930s

Population wtd NO₂ (ppb)

Air pollution in 2010 increases with 1930s redlining grade

Lane et al. 2022
Redlining and Air Quality

Nardone et al., 2020
Air Quality Adaptation

HOW PLANTS CAPTURE PARTICULATE MATTER (PM)

Vegetation Barrier
Greenbelt scenarios in which vegetation acts as a barrier to air flow, altering airflow patterns and pollution plume trajectory in addition to deposition (Steffens et al. 2012) (Lin et al. 2012)

Deposition
The physical capture of particulate matter on the leaves and bark of trees and plants. The greater surface area and the rougher or stickier the leaf and bark, the higher the deposition rate (Fuller 2009).

Vegetated barriers are most effective if planted close to the pollution source in highly polluted areas.

Source: https://louisville.edu/greenheart
Extreme Heat

Heat is the **top cause** of natural weather-related death in the US. (NOAA 2017)

Climate change increases the frequency and severity of heat waves.

- Extreme Heat
- Heat-Related Illness
- Mental Health Impacts
- Respiratory Diseases
- Heart Disease
- Death

The public health consequences of extreme heat are severe.
1995 Chicago Heat Wave


1995 Chicago Heat Wave

Heat waves increase risk of death.

Heat waves exacerbate inequities.

Cook County, July 11–27, 1995:
Excess deaths compared with this time period during an average year: about 700
Deaths classified as “heat-related” on death certificates (not shown here): 465

Table 1—Age-Specific and Age-Adjusted Heat-Related Death Rates per 100,000 Population, by Race/Ethnicity: Chicago Residents, Mid-July Heat Wave, 1995

<table>
<thead>
<tr>
<th>Age, y</th>
<th>Non-Hispanic White</th>
<th>Non-Hispanic Black</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;55</td>
<td>27</td>
<td>4</td>
<td>73</td>
</tr>
<tr>
<td>55–64</td>
<td>19</td>
<td>31</td>
<td>44</td>
</tr>
<tr>
<td>65–74</td>
<td>62</td>
<td>75</td>
<td>137</td>
</tr>
<tr>
<td>75–84</td>
<td>97</td>
<td>119</td>
<td>216</td>
</tr>
<tr>
<td>&gt;84</td>
<td>47</td>
<td>222</td>
<td>259</td>
</tr>
<tr>
<td>Total²</td>
<td>242</td>
<td>11</td>
<td>514</td>
</tr>
</tbody>
</table>

*Non-Hispanic Black to non-Hispanic White ratio.
²Standardized to the 1940 US population.

Whitman et al., 1997
Extreme Heat

TABLE 2. Number and rate of heat-related deaths,\* by race/ethnicity and level of urbanization — United States, 2004–2018

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. of deaths (rate)$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Race/Ethnicity</strong></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>1,349 (0.2)</td>
</tr>
<tr>
<td>American Indian/Alaska Native, non-Hispanic</td>
<td>241 (0.6)</td>
</tr>
<tr>
<td>Asian/Pacific Islander, non-Hispanic</td>
<td>194 (0.1)</td>
</tr>
<tr>
<td>Black, non-Hispanic</td>
<td>1,965 (0.3)</td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>6,602 (0.2)</td>
</tr>
<tr>
<td>Not stated**</td>
<td>176 (N/A)</td>
</tr>
<tr>
<td><strong>Level of urbanization</strong></td>
<td></td>
</tr>
<tr>
<td>Large central metro</td>
<td>4,402 (0.3)</td>
</tr>
<tr>
<td>Large fringe metro</td>
<td>1,607 (0.1)</td>
</tr>
<tr>
<td>Medium metro</td>
<td>1,764 (0.2)</td>
</tr>
<tr>
<td>Small metro</td>
<td>990 (0.2)</td>
</tr>
<tr>
<td>Micropolitan</td>
<td>879 (0.2)</td>
</tr>
<tr>
<td>Noncore</td>
<td>885 (0.3)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>10,527 (0.2)</td>
</tr>
</tbody>
</table>

Vaidyanathan et al., 2020

APHA, 2018

Taylor et al., 2018
# Cardiovascular Disease (CVD) and Heat

## TABLE 3. Selected underlying causes* of death for which heat-related conditions were listed as a contributing factor† — United States, 2004–2018§

<table>
<thead>
<tr>
<th>Underlying cause of death†</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major cardiovascular diseases**</td>
<td>2,112 (49)</td>
</tr>
<tr>
<td>Hypertensive diseases</td>
<td>438 (10)</td>
</tr>
<tr>
<td>Ischemic heart diseases</td>
<td>1,463 (34)</td>
</tr>
<tr>
<td>Other cardiovascular diseases</td>
<td>211 (5)</td>
</tr>
<tr>
<td>External causes of morbidity and mortality††</td>
<td>1,543 (36)</td>
</tr>
<tr>
<td>Alcohol poisoning deaths</td>
<td>130 (3)</td>
</tr>
<tr>
<td>Drug overdose deaths</td>
<td>643 (15)</td>
</tr>
<tr>
<td>Other external causes of morbidity and mortality</td>
<td>770 (18)</td>
</tr>
<tr>
<td>Mental and behavioral disorders§§</td>
<td>174 (4)</td>
</tr>
<tr>
<td>Mental and behavioral disorders due to psychoactive substance use</td>
<td>151 (4)</td>
</tr>
<tr>
<td>Other mental and behavioral disorders</td>
<td>23 (0)</td>
</tr>
<tr>
<td>Diseases of the respiratory system §§</td>
<td>127 (3)</td>
</tr>
<tr>
<td>Chronic lower respiratory diseases</td>
<td>116 (3)</td>
</tr>
<tr>
<td>Other diseases of the respiratory system</td>
<td>11 (0)</td>
</tr>
<tr>
<td>Endocrine, nutritional, and metabolic disorders ***</td>
<td>128 (3)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>78 (2)</td>
</tr>
<tr>
<td>Other endocrine, nutritional, and metabolic disorders</td>
<td>50 (1)</td>
</tr>
<tr>
<td>Diseases of the digestive system §§§</td>
<td>48 (1)</td>
</tr>
<tr>
<td>Diseases of the liver</td>
<td>33 (1)</td>
</tr>
<tr>
<td>Other diseases of the digestive system</td>
<td>15 (0)</td>
</tr>
<tr>
<td>Genitourinary disorders §§§</td>
<td>30 (1)</td>
</tr>
<tr>
<td>Musculoskeletal disorders §§§</td>
<td>12 (0)</td>
</tr>
<tr>
<td>Other diseases</td>
<td>133 (3)</td>
</tr>
<tr>
<td>Total underlying causes of death with heat-related conditions**** as a contributing factor</td>
<td>4,307 (100)</td>
</tr>
</tbody>
</table>

Vaidyanathan et al., 2020
Redlining and Heat

HOLC security rating
Green = “Best,” A;
Blue = “Still Desirable,” B
Yellow = “Declining,” C
Red = “Hazardous,” D

Hoffman et al, 2020
Urban Heat Island

- High thermal mass – concrete and blacktop roads
- Low ventilation – urban canyons, tall buildings
- Point source – vehicle and air conditioner heat
- Heat absorption – higher night temperatures

Luber and McGeehin, 2008

Socioeconomic Status
Social Determinants of Health

CLIMATE CHANGE
## Urban Heat Island Effect in Louisville

### Top 10: Most intense urban heat islands (2004-2013)
- Las Vegas (7.3°F)
- Albuquerque (5.9°F)
- Denver (4.9°F)
- Portland (4.8°F)
- Louisville (4.8°F)
- Washington, DC (4.7°F)
- Kansas City (4.6°F)
- Columbus (4.4°F)
- Minneapolis (4.3°F)
- Seattle (4.1°F)

### Top 10: Most intense overnight urban heat islands (2004-2013)
- Las Vegas (10.3°F)
- Albuquerque (9.7°F)
- Portland (8.9°F)
- Washington, D.C. (7.1°F)
- San Diego (7.1°F)
- Louisville (7.0°F)
- Phoenix (6.8°F)
- Buffalo (6.4°F)
- Minneapolis (6.1°F)
- Philadelphia (6.0°F)

### Top 10: Most days above 90°F compared to nearby rural areas
- Dallas (39 more days above 90°F)
- Baton Rouge (26 more days above 90°F)
- Denver (26 more days above 90°F)
- Albuquerque (25 more days above 90°F)
- Nashville (25 more days above 90°F)
- Louisville (23 more days above 90°F)
- Las Vegas (22 more days above 90°F)
- Austin (22 more days above 90°F)
- Oklahoma City (22 more days above 90°F)
- Dayton (21 more days above 90°F)

### Top 10: Cities with fastest-growing urban heat islands
- Columbus (0.84°F per decade)
- Minneapolis (0.77°F per decade)
- Baltimore (0.66°F per decade)
- Louisville (0.65°F per decade)
- St. Louis (0.64°F per decade)
- Wichita (0.60°F per decade)
- Birmingham (0.58°F per decade)
- New Orleans (0.56°F per decade)
- Des Moines (0.56°F per decade)
- Oklahoma (0.55°F per decade)

### Top 10: Cities with fastest-growing overnight urban heat islands
- Las Vegas (0.95°F per decade)
- Albuquerque (0.93°F per decade)
- New Orleans (0.82°F per decade)
- Minneapolis (0.81°F per decade)
- Norfolk (0.78°F per decade)
- Birmingham (0.66°F per decade)
- Jacksonville (0.65°F per decade)
- Philadelphia (0.64°F per decade)
- Louisville (0.61°F per decade)
- St. Louis (0.61°F per decade)

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**Summer in the City**

**Louisville**

- **Up to 20.0° HOTTER IN THE CITY THAN IN NEARBY RURAL AREAS**
- **Average 4.8° CITY SUMMERS ARE HOTTER THAN IN RURAL AREAS**
- **23 MORE DAYS ABOVE 90° EACH YEAR, THAN RURAL AREAS**

**No.5 BIGGEST DIFFERENCE BETWEEN URBAN AND RURAL TEMPERATURES**

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**Climate Central, 2014**
Figure 1. Average warm season (May through September 2012) daily (A) high and (B) low temperatures (°F). 
Note: The Ohio River is the western boundary of the Louisville Metro, running from the southermost point to the northermost point of the region. 
CBD = central business district. 
Stone, Jr. et al, 2019

Figure 3. Distribution of estimated UH-attributable heat mortality in Louisville urban core neighborhoods by grid cell during May to September of 2012. 
EMPhW, 2018, 2019
Green Heart Project

Louisville’s air quality ranks among the worst in Kentucky.

And our current tree canopy is only 37%.
Meaningful Partnerships

Green Heart Louisville Community Advisory Board

Community Advisory Board virtual meeting

Community partner sharing with the CAB

CAB member representing Green Heart at a community event

CAB member discussing Green Heart

Shared Leadership

Bi-directional Education

Participation

Engagement
Meaningful Partnerships

**Community Advisory Board**
South Louisville residents meet quarterly, help determine community engagement activities, and participate in Green Heart Louisville events.

**Community Organizations**
- Louisville Grows
- Neighborhood associations
- Local schools
- Faith-based organizations

**Activities**
- Health screenings
- Conversation Club
- The Canopy Newsletter
- Art and Literature Showcase
Lessons Learned

Challenges

Competing priorities

Multiple viewpoints
Overcoming Barriers

- TREE SELECTION
- TREE ASSISTANCE FUND
- STRATEGIC PARTNERSHIP
Hypothesis: Increased area greenness changes temperature gradients within an urban neighborhood.

<table>
<thead>
<tr>
<th>Temperature Exposure</th>
<th>Greenness</th>
<th>CVD Risk</th>
</tr>
</thead>
</table>
| • Ambient temperature within 300m of residence  
• Temperature variability (standard deviation of daily temperatures) | • NDVI  
• Tree canopy  
• LiDAR | • CVD risk biomarkers (blood pressure, lipids, glucose regulation)  
• Vascular function and injury (arterial stiffness, endothelial microparticles)  
• Inflammation (hsCRP, fibrinogen)  
• Immunity (immune cell populations) |

hsCRP – High-Sensitivity C-Reactive Protein, NDVI – Normalized Difference Vegetation Index, LiDAR – Light Detection and Ranging
Examining Disparities in the Green Heart Study

**Hypothesis:** Discrimination will modify the relationship between environmental exposures and cardiovascular disease risk.

<table>
<thead>
<tr>
<th>Exposures</th>
<th>CVD Risk</th>
<th>Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatile Organic Compounds (VOCs)</td>
<td>CVD risk biomarkers (blood pressure, lipids)</td>
<td>Discrimination</td>
</tr>
<tr>
<td>PM$_{2.5}$, Ozone</td>
<td>Vascular function (arterial stiffness)</td>
<td>Everyday and lifetime discrimination</td>
</tr>
<tr>
<td>Greenness</td>
<td>Inflammation (hsCRP, fibrinogen)</td>
<td>(occurrence/frequency, attribution, coping)</td>
</tr>
</tbody>
</table>

hsCRP – High-Sensitivity C-Reactive Protein

Discrimination
- Everyday and lifetime discrimination (occurrence/frequency, attribution, coping)

Mental stress
- Questionnaire, urine catecholamine metabolites, depression, well-being, social cohesion
What’s In The Air?
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