
## Urban Heat Island

# Trees and Air Quality: Six Methods to Get SIP Credit for Trees

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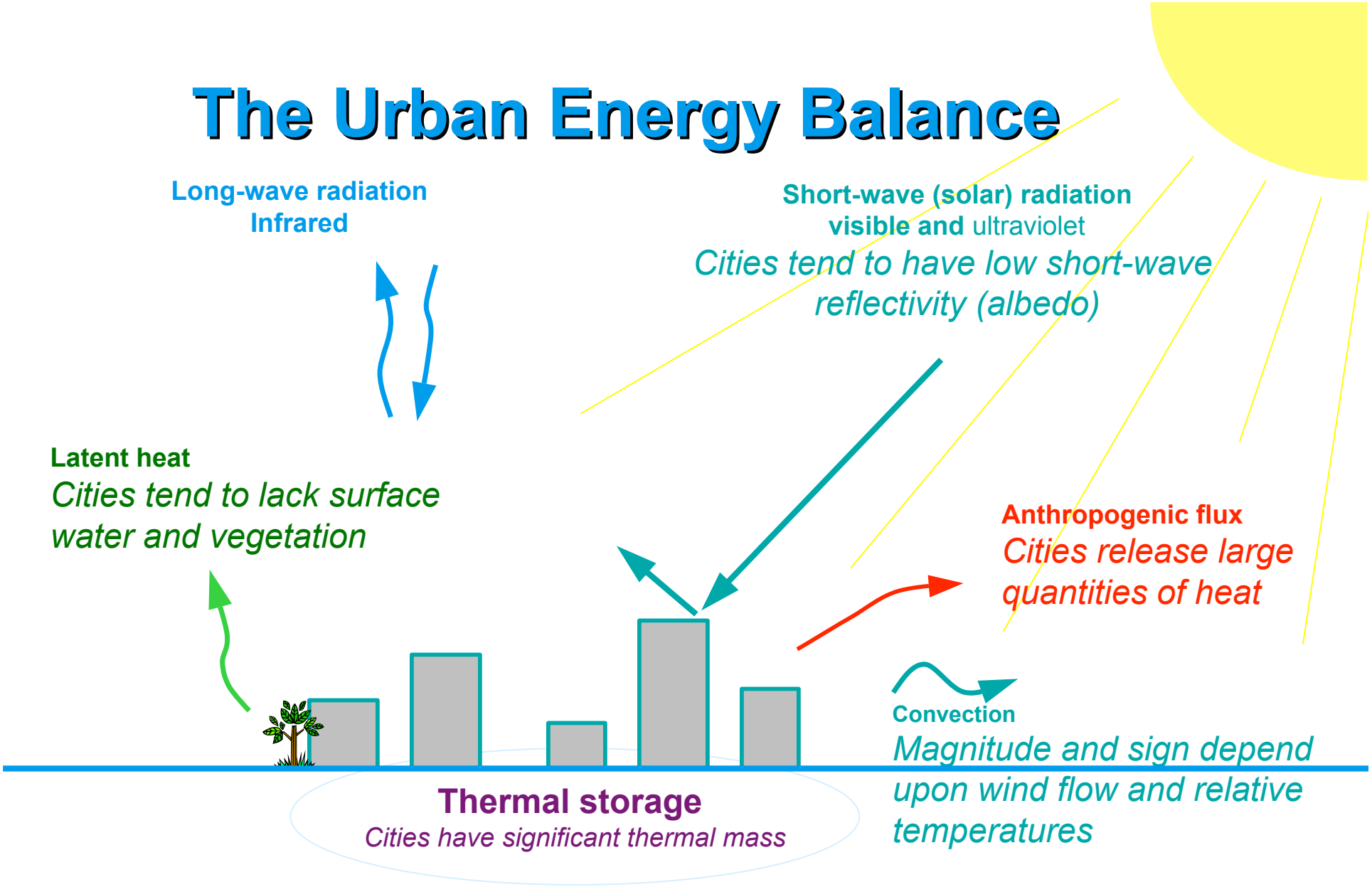
# The Urban Energy Balance




## Bottom Line:

## Cities gain and produce more heat than is lost.

# Heat Island Impacts

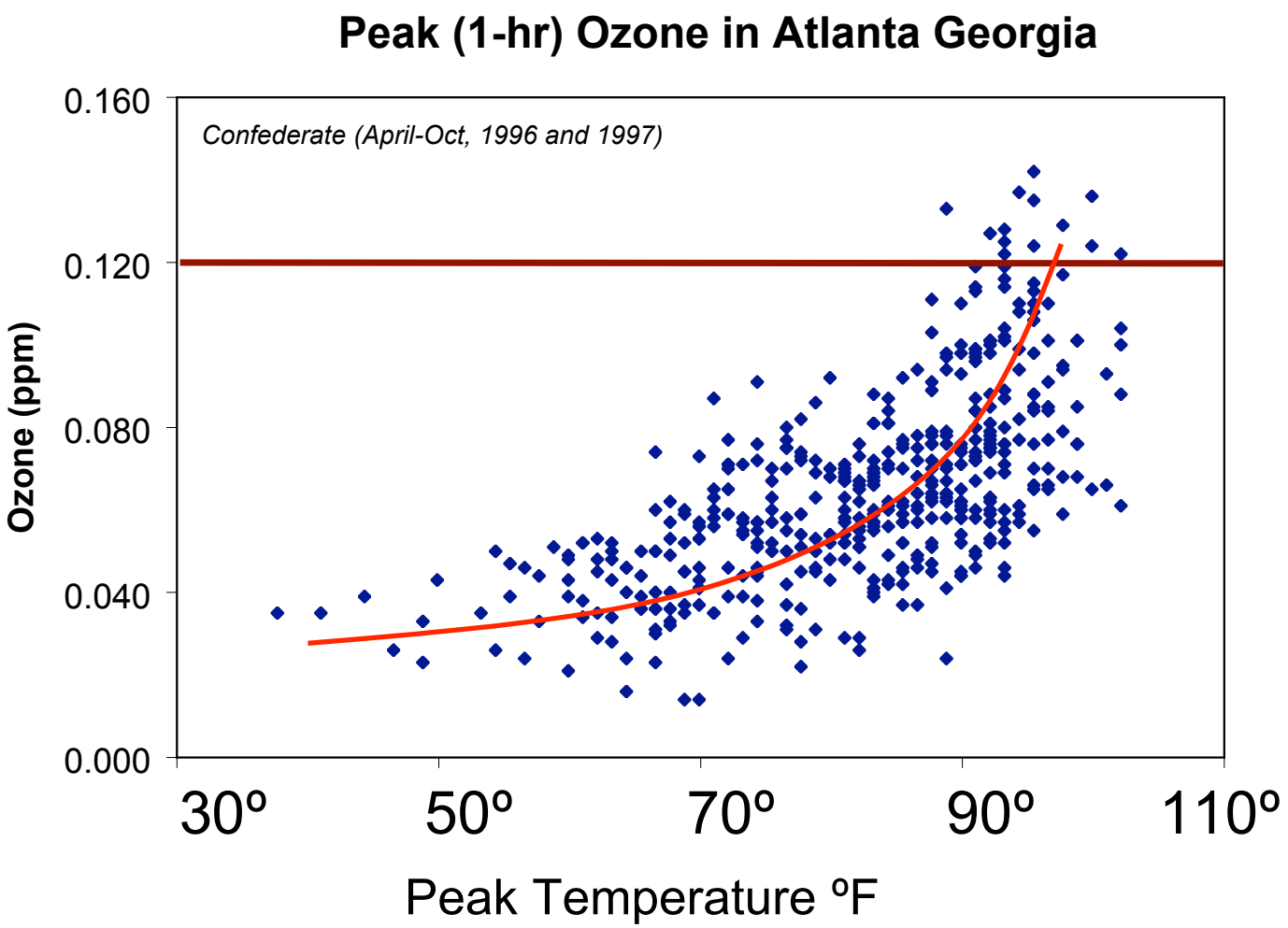

- Higher temperatures
- Higher ozone levels
- Higher energy bills
- Health effects
- Quality of life effects

# Heat Island Impacts
# Temperature and Ozone

Cool Houston!

## Other Effects

- Emissions
- Mixing heights
- Wind speeds
- Convection



# Heat Island Impacts
# Electric Power Use

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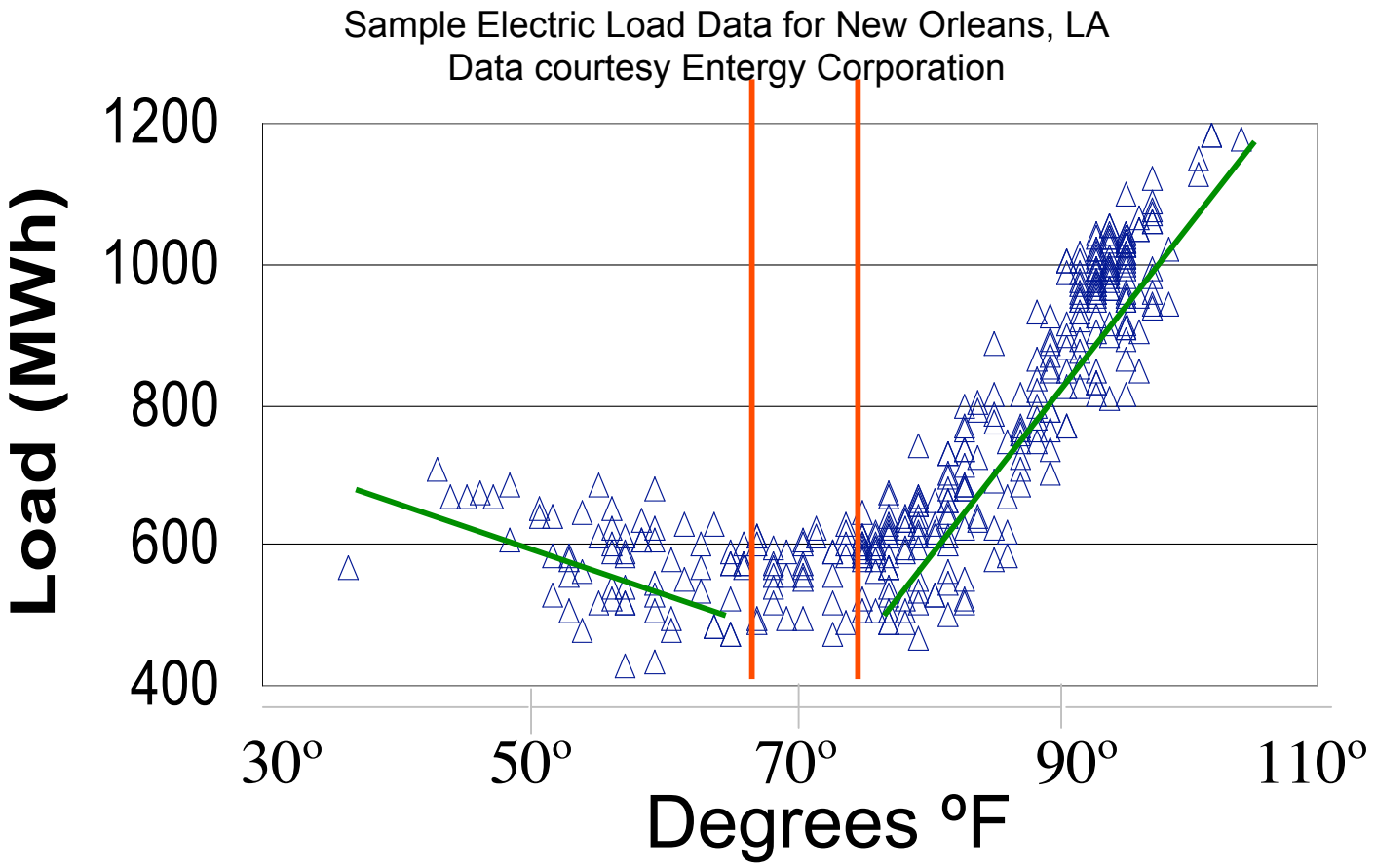
- Total and peak loads affected
- Extra generation capacity required



# Heat Island Humor?

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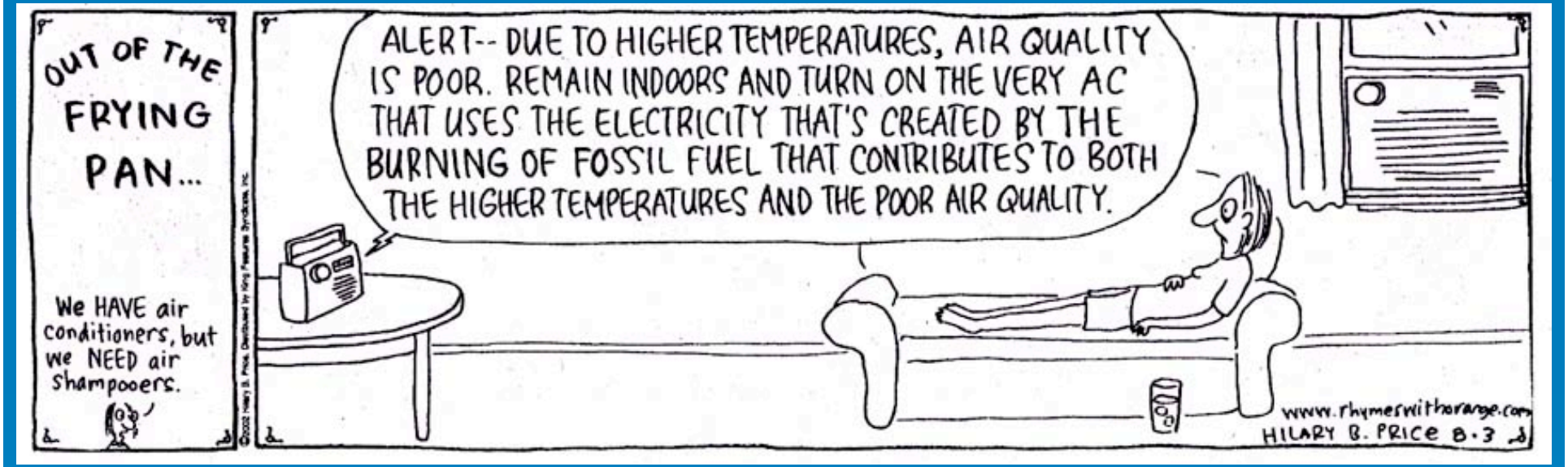

# Heat Island Impacts
# Human Health

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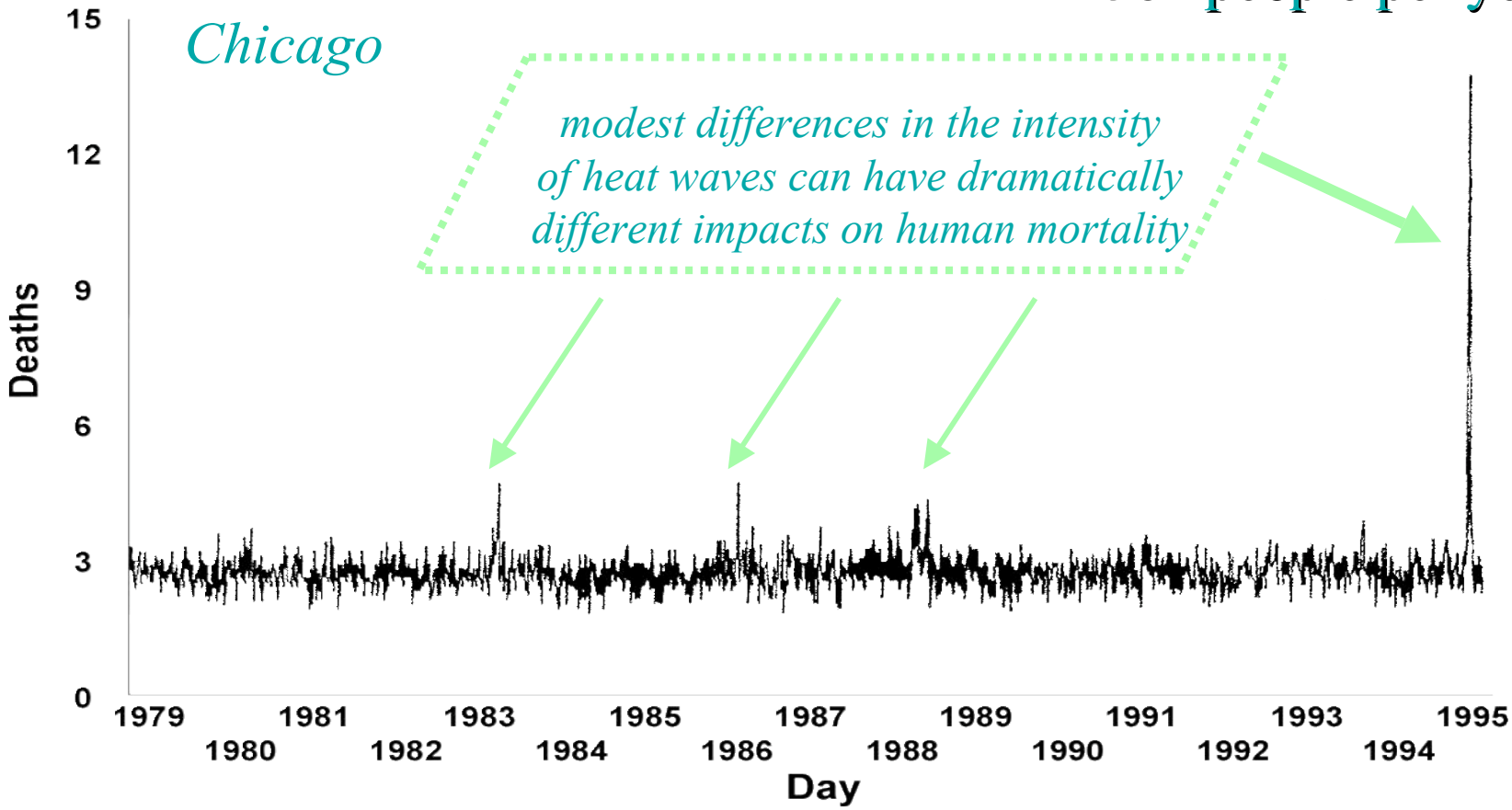
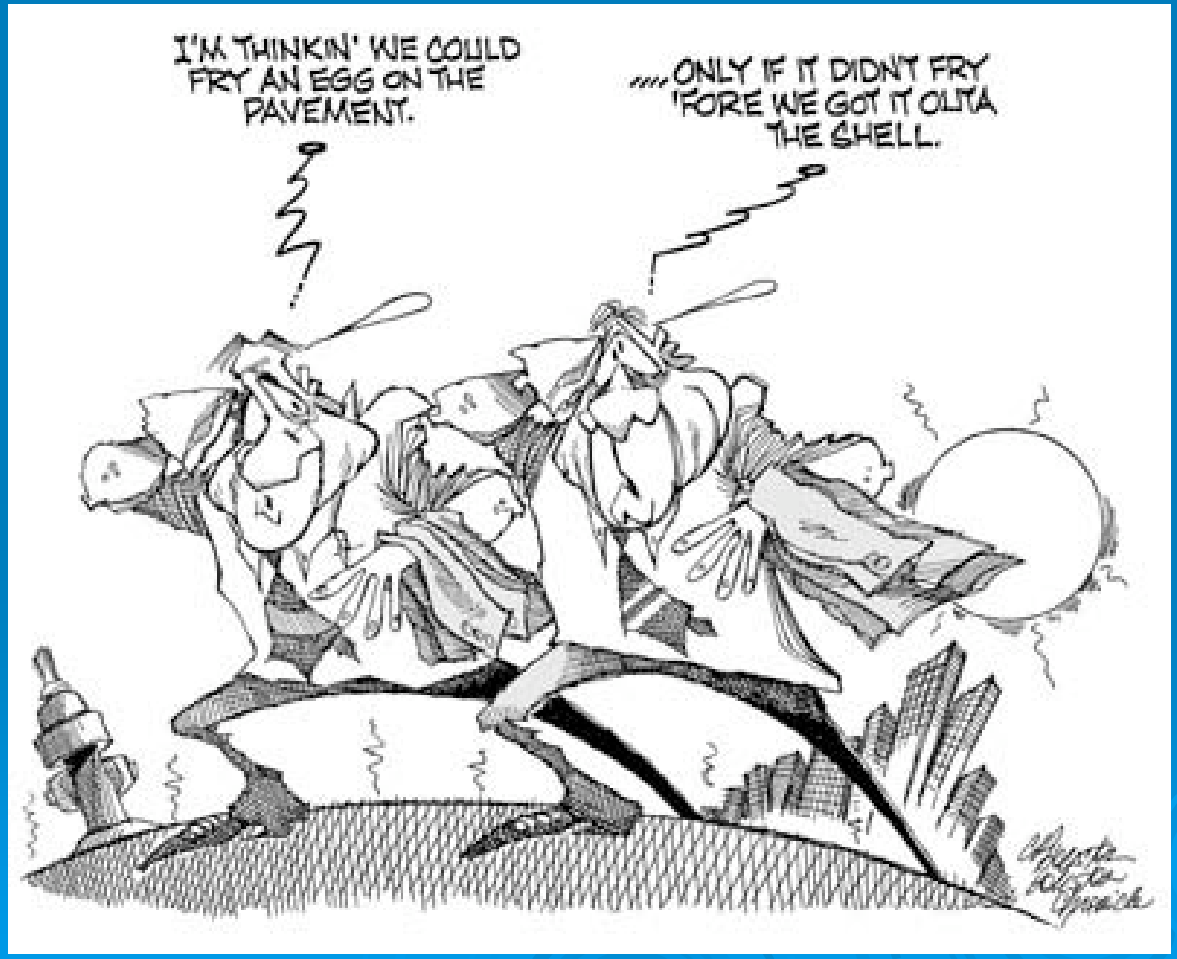
In the U.S., heat related deaths average 381 people per year

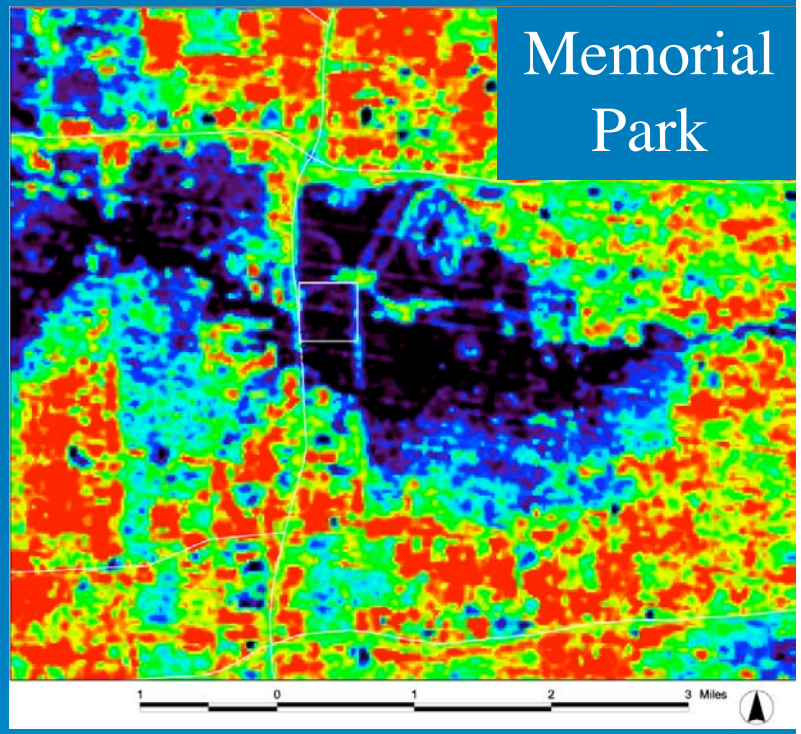


# Chronicle Humor?



# Heat Island Premises

- Premise 1: Urban climates have been changed.
  - Temperature
  - Soil moisture
  - Cloud cover
  - Lightning
  - Rainfall patterns
  - Mixing height
  - Wind speeds




- Premise 2: Urban climates can be changed again to reduce the effects.

# Changing the Urban Climate


- Changing the urban climate = changing urban surfaces
  1. Installing more reflective, less heat absorbing materials
     - Reflective roofing
     - Reflective paving surfaces
  2. Adding vegetation/soft fabric for cooling effects
     - Forestation
     - Preservation of trees
     - Green roofs
     - Porous paving

# Effect of 15 Years of Tree Loss on Ozone Levels Atlanta


| | $O_3$ (ppb) |
|---|---|
| • Maximum $O_3$: June 4, 1984 (base case) | 123 |
| • Reduction in $O_3$ due to loss of trees (-7 ppb) | 116 |

Tree loss reduces biogenic emissions which reduces ozone.

BUT temperatures INCREASE and RAISE ozone levels.

The results: 14% INCREASE:

| | |
|---|---|
| • Photochemical reactions (+5 ppb) | 121 |
| • Biogenic emission effect (+16 ppb) | 137 |
| • Anthropogenic emission effect (+3 ppb) | 140 |
| Total Increase Due to Tree Loss | 17 ppb |

(Cardelino and Chameides, 1990)

# Role of Trees in Air Quality


- Add emissions of natural VOCs
  - Terpene and isoprene
- Remove ozone through deposition
- Use solar energy in energy balance
- Shade buildings and rooftops
  - Reduces energy use
- Shade surfaces that would absorb energy
  - Rooftops, paved surfaces, air conditioning units
- Reduce equipment used for mowing
- Shade vehicles reducing evaporative emissions

# SIP Requirements for Credit
# Must Meet All Four


- Quantifiable
  - Credible, defensible, replicable
  - Demonstrated in modeling
- Permanent
  - Won't end when program ends
- Surplus
  - Not counted elsewhere
  - No double counting
- Enforceable
  - Against a source
  - Against a party - governmental entity
  - Voluntary - limited credit

# Six Possible Tree SIP Credits


1. Tree VOC emissions
2. Ozone deposition
3. Energy savings from tree shade
4. Mowing emission reductions
5. Evaporative emission reductions
6. Heat island temperature reductions

# 1. Emissions of Natural VOCs

## The absurd but relevant example

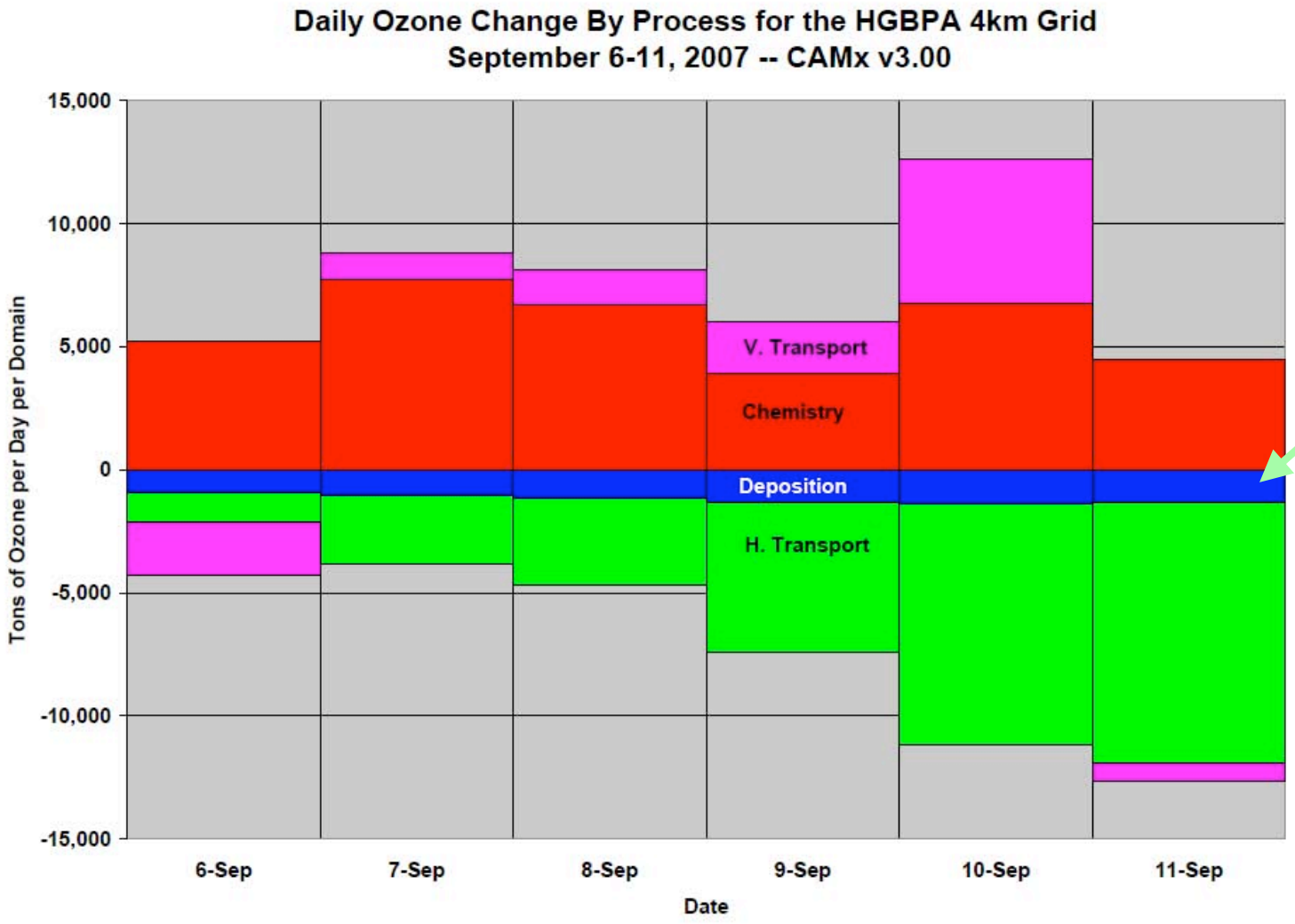
- Trees are planted and destroyed.
- VOC reductions occur with tree loss
  - Tree loss would be a "benefit' under a system that tracks the tree inventory.
  - Air quality credits could be given for removing trees.
  - Quantifiable/permanent/surplus??/ enforceable????
- The Atlanta modeling demonstrates that the net effect of tree loss is MORE ozone.
- SIP control measure credits are driven by "emission reduction thinking" not "ozone reduction"

# 2. Deposition as a SIP Credit

- Modeling difficulties!!!
- Deposition is part of air chemistry modeling.
- Modeling treats trees as a constant - no growth or death; not planted or destroyed.
- This doesn't matter much, unless . . . .
- trees are proposed as SIP control measure.
- Nevertheless, trees provide a large positive benefit from deposition.
- If a tree is lost, there is less ozone removed.
- If trees are added (or conserved), there is more ozone removed by deposition.
- Quantifiable/permanent/surplus?/enforceable ??

"Now let's go to the meteorologist with today's guess."

# Deposition and Ozone Fate




Trees remove ozone through deposition

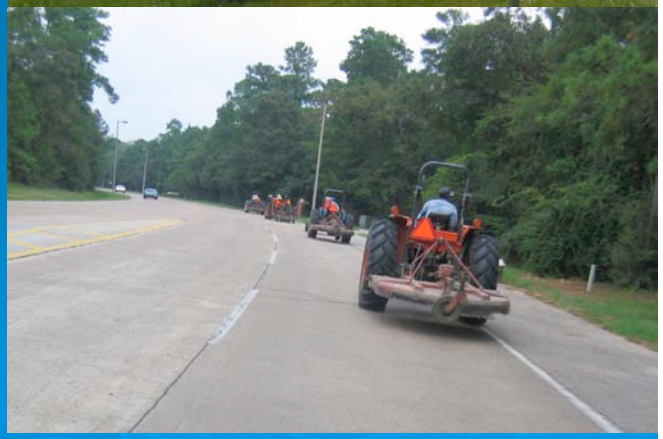
Roughly 15% to 33% of that formed by air chemistry.

# 3. Energy Savings from Shade

- 6% to 15% benefit
- 1-2 tons day NOx reductions
- Do emission reductions occur and where?
- Cap and trade issues in Houston is major barrier to SIP credit
- New 8/04 EPA guidance might help.
- Quantifiable/permanent/surplus?/ enforceable?

# 4. Mowing Emission Reductions

- Replace mowed areas with trees and low maintenance vegetation
- Reduce mowing/blowing emissions
- Primarily VOCs
- Quantifiable/permanent/ surplus/enforceable



# How Much?
## lbs/acre/mowing

| Landscape Maintenance Activity | VOCs | $NO_x$ |
|---|---|---|
| Mowing | 0.58 | 0.14 |
| Blowing | 1.47 | 0.19 |
| Trimming | 1.33 | 0.01 |
| Total | 3.38 | 0.34 |


Source: Clean Air Counts - Chicago

# 5. Evaporative Emission Reductions

- Parking in the shade
- 2% VOC reduction with 50% canopy - Sacramento studies
- Slight NOx benefit
- Other benefits
- Quantifiable/permanent/ enforceable?/surplus

Finding a shaded spot

# 6. Heat Island Ozone Reductions


- Most comprehensive view of heat island impacts
  - Added trees and increased reflectivity
  - Improved modeling of land use/land cover change at U of H puts levels in the 10 ppb range or roughly 5% to 8% benefit
  - Not included
    - power plant emission reductions
    - evaporative emission reductions
    - thermal mass energy reductions
- Large modeling challenges remain particularly with meteorology
- Large policy challenges remain with inclusion of tree/vegetation inventory
- Quantifiable???/permanent/enforceable??/surplus?

# Summary of Functions


| Tree Functions | Unique Impact | Unique Air Quality Impact | Level of Certainty |
|---|---|---|---|
| 1. VOC emissions from trees | Adds VOC emissions | VOC emission source | High |
| 2. Ozone deposition | Removes ozone | Direct ozone reduction | High |
| 3. Shading of buildings | Reduces summertime energy use | Indirectly reduces power plant emissions | High |
| 4. Mowing/lawn offsets | Reduces/eliminates mowing | Directly reduces lawn and garden emissions | High |
| 5. Evaporative emissions shade | Reduces temperature of vehicles and fuel | Indirectly reduces evaporative and start-up emissions | High |
| 6. Comprehensive Heat Island Effects<br>Trees plus other measures | Lower temperatures plus complex changes to meteorology and air chemistry | Lowers ozone levels through direct and indirect methods | Medium |

# What is Enough?


- 660 million trees in the region
- Losing 2 - 4 million per year?
- New tree growth largely invasives (tallow)
- Regional plans suggest adding a million trees per year
- Public and non-profit sector add 100,000 to 200,000 per year (guesstimate)
- Individuals add ??,000 per year

- How do we get to millions of trees per year?

# With New Tree Strategies


- Measure and capture private sector tree planting - need baseline
- Use the Internet
  - web-based tree planting for measurement, tracking and promotion
- Create new private-public partnerships
  - Vertical market solutions from tree growing to tracking
  - Venture capital?
- Promote large scale forestation efforts through market mechanisms
- Change parts of the system that ignore conservation
  - Not bad people • bad systems

# Conclusions


- There are systematic, cost effective actions to alter an urban fabric.
- Heat island mitigation components, such as cool roofing and trees, provide a large stream of benefits than can be tapped to change an urban climate.
- The scope and amount of time required for such changes is as short as 10 years.
- Focus and continuity of effort are essential.

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