



The science behind reforestation as an ozone control strategy

Mark Estes

TCEQ

March 10, 2006

Hypotheses

- Large-scale planting of trees in an urban area will reduce temperatures.
- Lower temperatures will slow ozone chemistry, reduce some types of emissions, and cut power plant emissions by reducing energy usage. All of these effects will reduce ozone formation.
- Reforestation will also remove more ozone and its precursors from the air via dry deposition.

Other effects of reforestation

- Reforestation will increase biogenic emissions, resulting in more VOCs available for reaction with anthropogenic NO_x, thus increasing ozone formation.
- Decreasing temperatures will decrease the vertical mixing of air over the city, resulting in greater stagnation, and fewer clouds, thus increasing ozone formation.

Testing the competing effects

- Because there are potential benefits and disbenefits, we need to test all of the effects of reforestation, in order to see which ones are most likely to dominate in Houston.
- The best way to test all of the effects together is through meteorological and photochemical modeling. This is also the way to quantify ozone benefits for the SIP.

Houston urban heat island studies

- University of Houston (Byun et al., 2004, 2005). Collaboration with Texas Forest Service, US Forest Service, GEM, San Jose State Univ., and TCEQ.
- University of Texas (Allen et al., 2004)
- Lawrence Berkeley Lab (Emery and Tai, 2002; Taha, 2000)

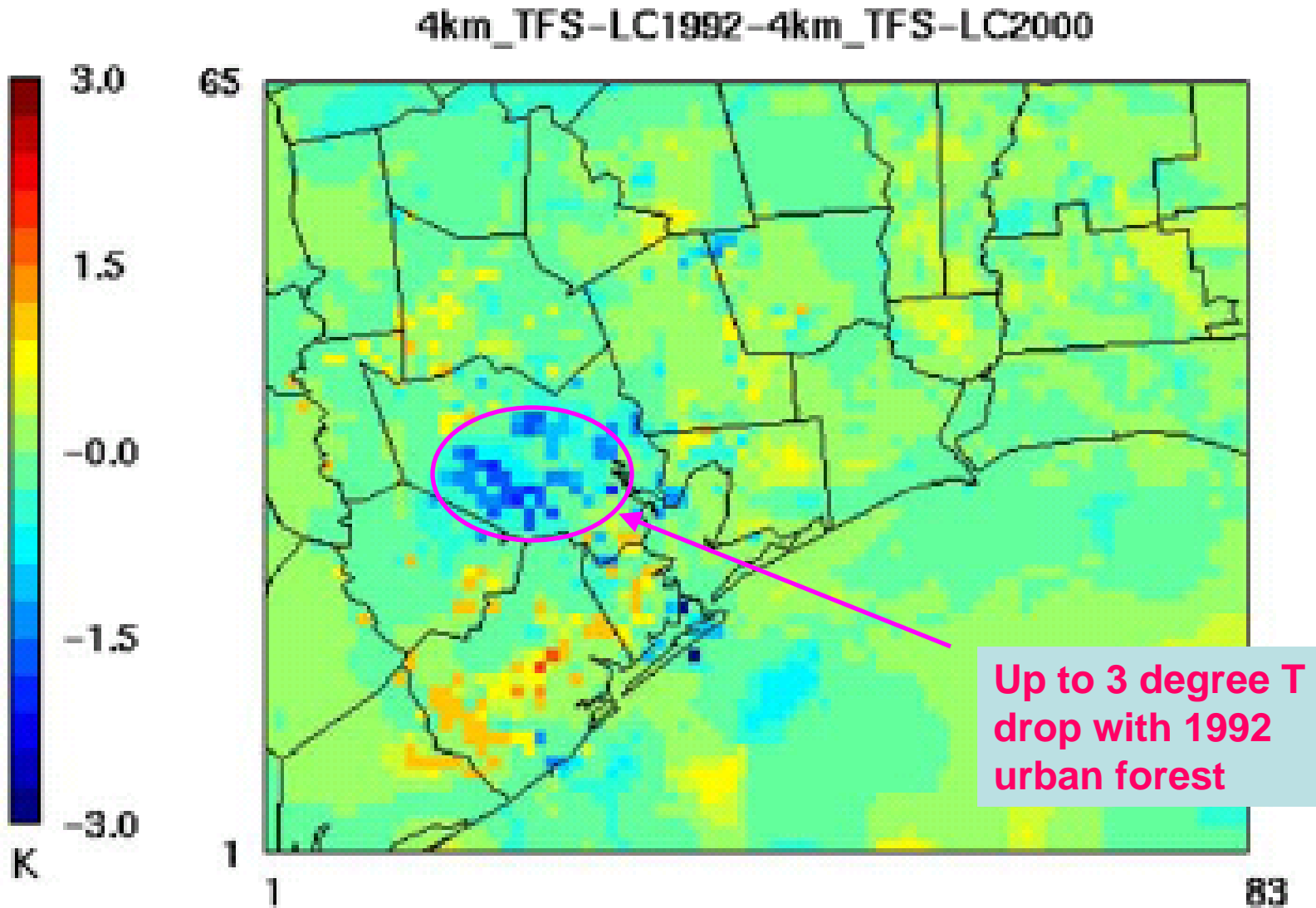
Byun et al., 2005 study

- The most sophisticated study of urban heat island effects on Houston. It considered the effects of reforestation on urban temperature, winds, vertical mixing, and other meteorological effects, dry deposition, ozone chemistry, and biogenic emissions.

Methods

- Land cover data from 2000 was extrapolated backward to 1992, using the USGS NLCD data to constrain the extent of the urban and forested areas.
- Ozone episode used in 2004 Houston SIP was modeled with two different land cover scenarios: 1992 land cover with 2000 anthropogenic emissions, and 2000 land cover with 2000 anthropogenic emissions.
- More tree cover in 1992 than 2000.

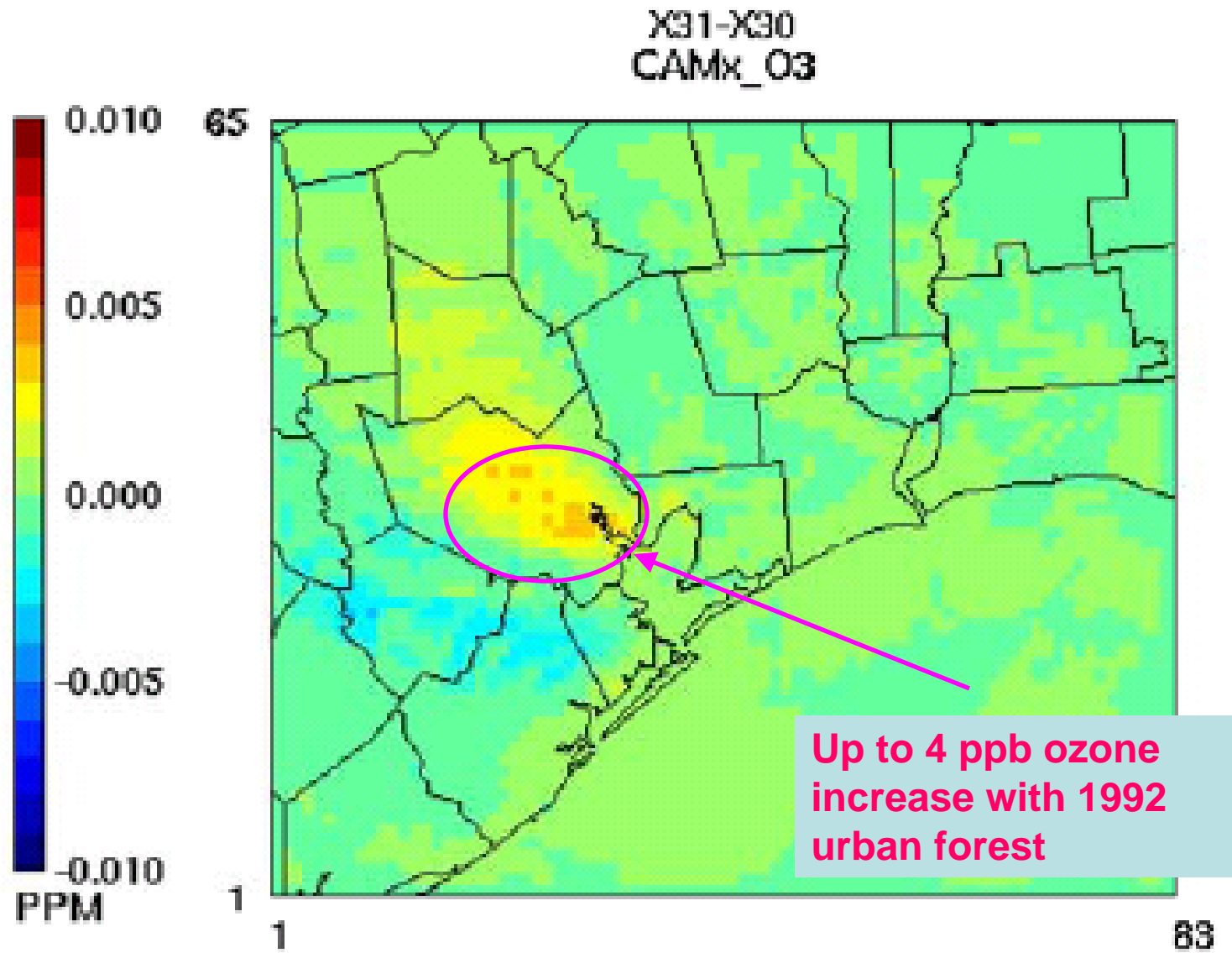
Temperature Difference: 1992 - 2000



From Byun et al., 2005

August 25, 2000 20:00:00
Min= -3.0 at (37,17), Max= 1.9 at (24,16)

Ozone Difference: 1992 - 2000



From Byun et al., 2005

August 25, 2000 0:00:00
Min=-0.003 at (8,24). Max= 0.004 at (29,31)

Effects of reforestation

- For Harris county, county-wide average temperature decreases of 0.2°C to 1.0°C.
- Area exceeding 8-hr standard increases by less than 5%, except for Aug 28, which decreases.
- Peak daily 1-hr ozone changes of -1.5 ppb to +0.9 ppb in Houston, for days with peak 1-hr ozone >125 ppb. On all days, peak ozone changes -1.5 ppb to +2.1 ppb.

Results do not support original hypothesis

- Reforestation decreases temperature, but increases ozone. Why?
- Biogenic VOC emissions increase in the urban area, where ozone formation is limited by the amount of VOCs available.
- When VOCs increase, ozone goes up.
- Lower temperatures yield less vertical mixing, resulting in higher concentrations of precursors (i.e., anthropogenic NO_x).
- The combination of these two effects seems to overwhelm the beneficial effects.

Other studies

- Allen et al., 2004 performed a quick study of reforestation/deforestation in selected areas of Houston. Both scenarios showed that more tree cover yields slightly higher ozone (~2ppb).
- Considered only the effects of reforestation on biogenic emissions, dry deposition, and ozone chemistry—no temperature effects. Results show that biogenic emission effects seem to dominate dry deposition effects.

Other studies

- Taha (2000) did a modeling study of the 1993 episode in Houston, and Emery and Tai (2002) reviewed and updated it.
- Considered effects of reforestation and albedo measures on temperature, winds, other meteorology, ozone chemistry, and dry deposition. No biogenic emission effects.

Results of Taha / Emery&Tai

- Temperatures increased (max 6°C) and decreased (max -3°C).
- Peak ozone increased by as much as 18 ppb in some areas, and decreased by as much as 8.5 ppb.
- Ozone increases due to increased temperatures and reduced vertical mixing, which led to greater stagnation and fewer clouds.

Conclusions

- Studies of reforestation in Houston do not consistently show that large-scale tree-planting will reduce ozone.
- These studies show that the simulated benefits from reforestation are smaller than the uncertainties inherent in this type of experimental modeling.