

The Weekend Ozone Effect: Reality vs. Conventional Wisdom

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Outline of Presentation

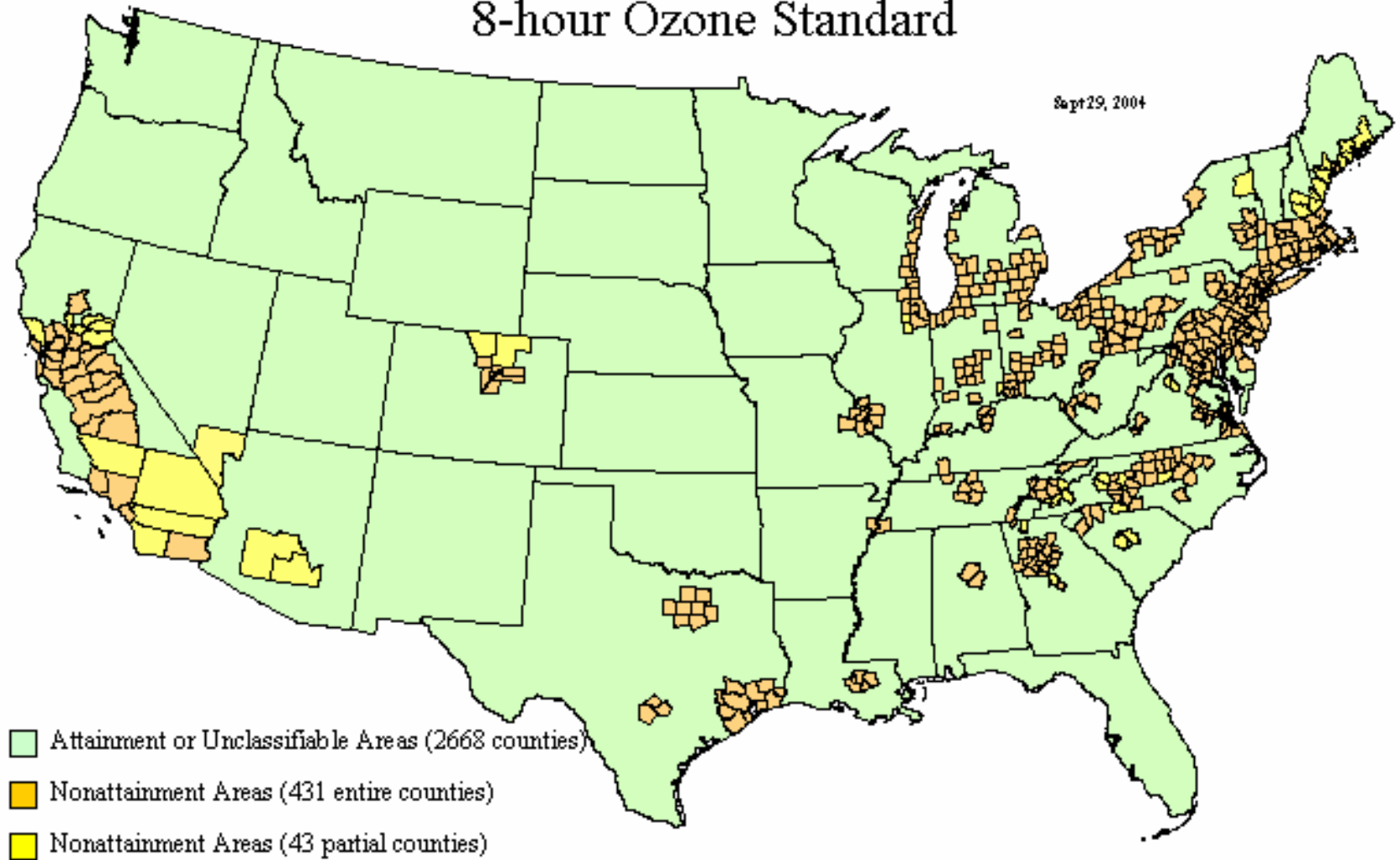
- Statement of Problem
- Outline of Our Study
 - Data Analysis
 - Hypotheses Tested
 - Emission Inventory Results
 - Field Study
 - Hypothesis Testing Results
- Study Conclusions
- Current Work

Statement of Problem

Ambient ozone levels are as high or higher on weekends than on weekdays in many urban U.S. locations, despite much lower emissions of the ozone precursors (hydrocarbons, carbon monoxide, and nitrogen oxides).

What's going on here?

Attainment and Nonattainment Areas in the U.S. 8-hour Ozone Standard



Source: EPA Green Book: www.epa.gov/oar/oaqps/greenbk/index.html

Observations

- Atmospheric scientists/policy makers usually cannot conduct controlled experiments of the kind that are needed to address policy-relevant issues.
- Emission changes that occur every Saturday and Sunday, relative to weekdays, provide the ideal “emissions control experiment.”
- In our study, we can distinguish weekends from weekdays, and even between Saturdays and Sundays.

Policy Questions

- Which is the most effective and least costly means of reducing ambient ozone in urban locations – NO_x controls, VOC controls, or both?
- When highest average ozone is on weekends, how do you design an effective strategy to reduce ambient ozone levels?

Overall Study Approach/Design

- Met with government/industry groups throughout study period to share information (<http://www.arb.ca.gov/aqd/weekendeffect/weekendeffect.htm>)
- Retrospective Analysis of Ambient Data
- Formulation of Study Hypotheses
- Emission Inventory Development
- Field Study
- Data Analysis
- Air Quality Simulation Modeling
- Publish Results in Peer-Reviewed Literature

DATA ANALYSIS

Ambient Air Quality Data Analysis

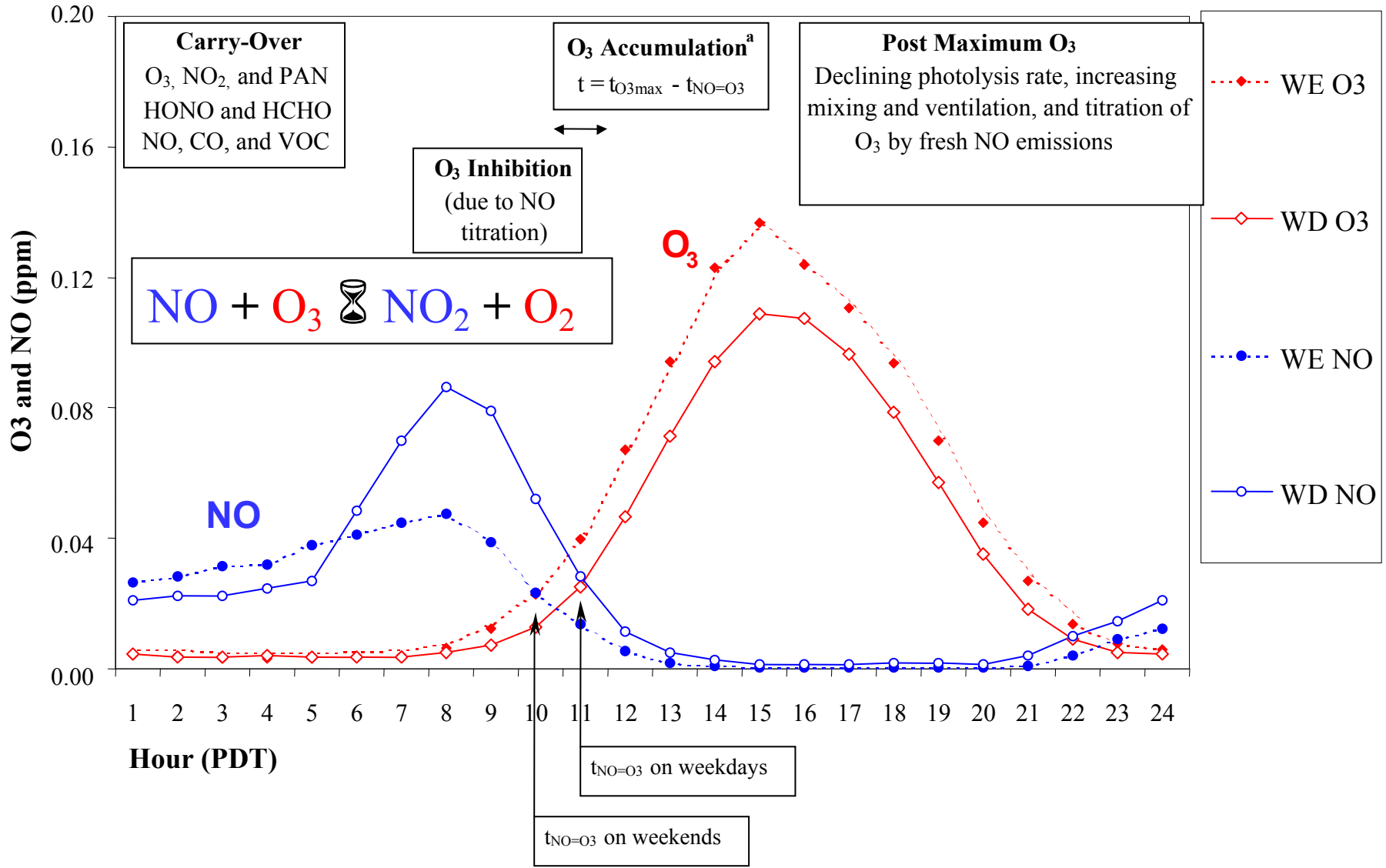
- At 78 southern California monitoring sites in five air basins, 28 had statistically significant **higher** Sunday O₃ levels, while 49 of the remaining 50 sites showed **no significant WD/WE differences**.
- Average Sunday NO_x and VOC concentrations at all monitoring sites were 25-41% and 16-30% **lower** than on weekdays, respectively.

Weekend/Weekday O₃ and NO Ratios

Location	Nitric Oxide (NO)	Ozone (O ₃)
<i>Saturday/Midweek</i>		
Los Angeles, N. Main	0.61	1.29
Pico Rivera	0.69	1.27
Azusa	0.51	1.31
Upland	0.62	1.26
<i>Sunday/Midweek</i>		
Los Angeles, N. Main	0.43	1.49
Pico Rivera	0.39	1.50
Azusa	0.29	1.55
Upland	0.29	1.44
<i>Four-Site Averages</i>		
Saturday/Midweek	0.61	1.28
Sunday/Midweek	0.35	1.50

Note: Midweek is average of Tue, Wed, and Thur values

Azusa, Summer 1995



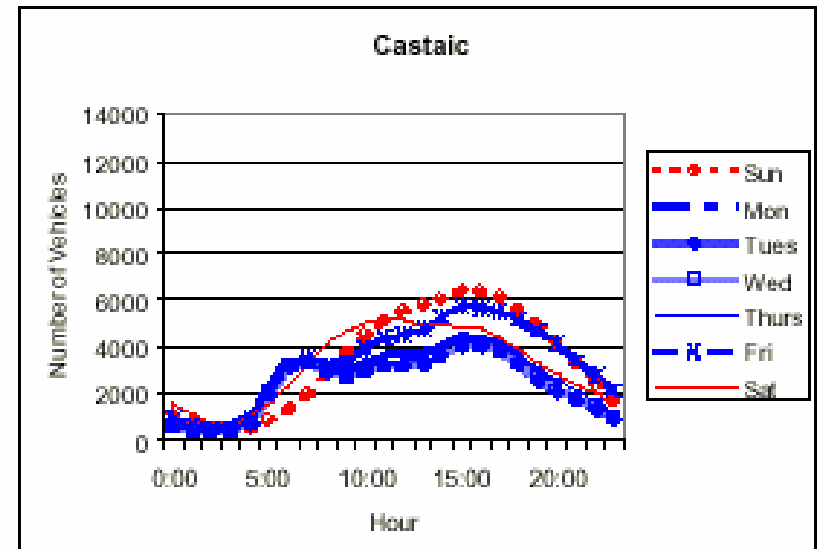
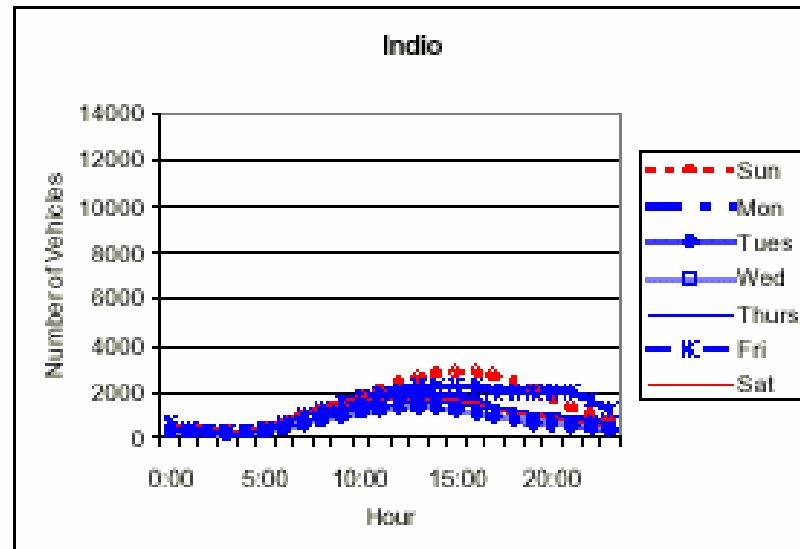
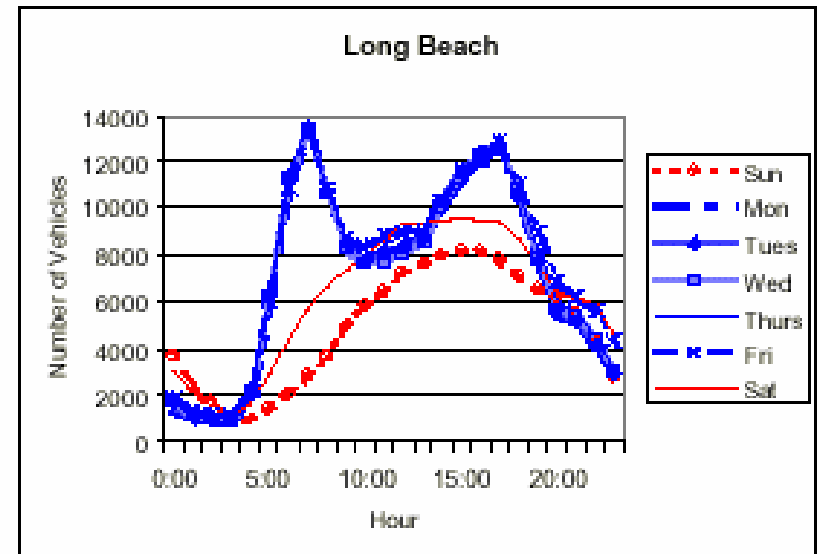
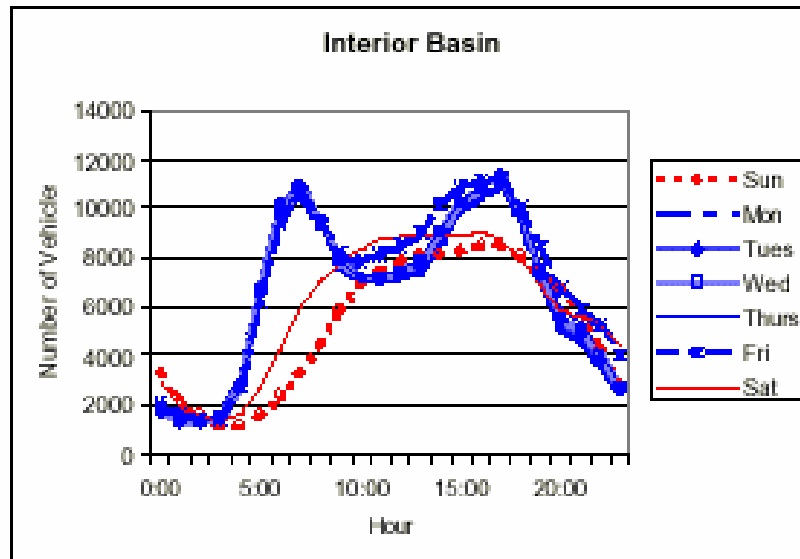
FORMULATION OF STUDY HYPOTHESES

Hypotheses Tested in our Study

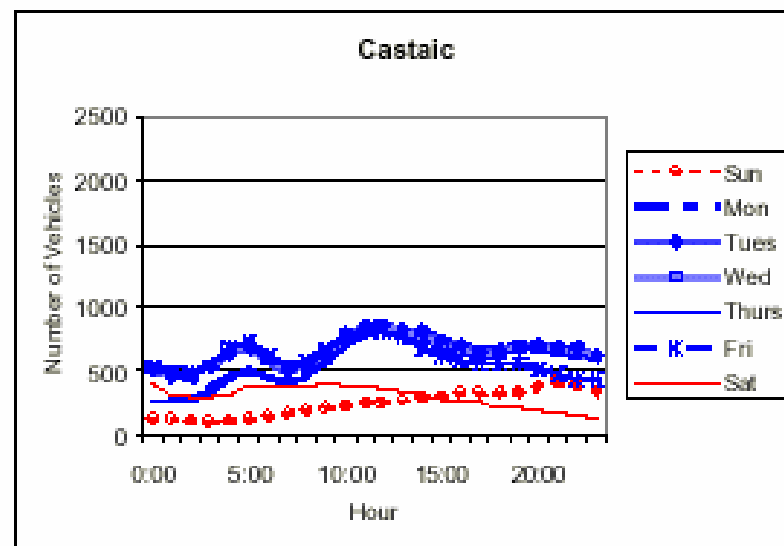
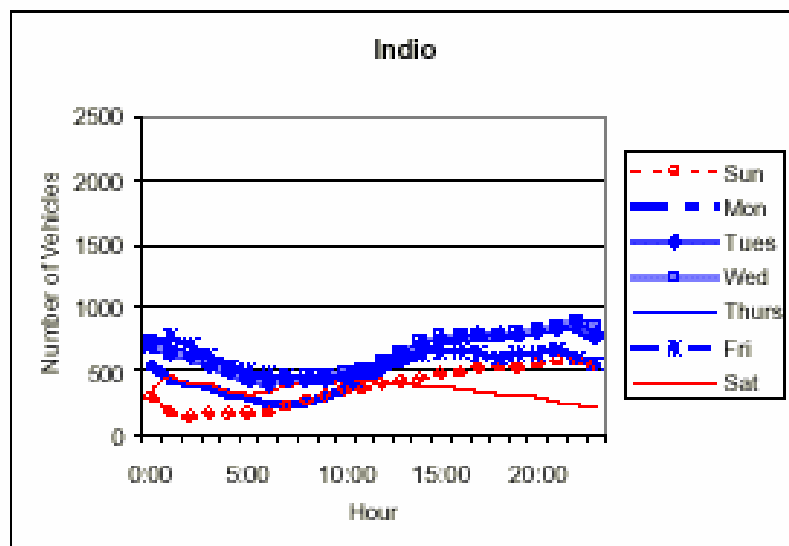
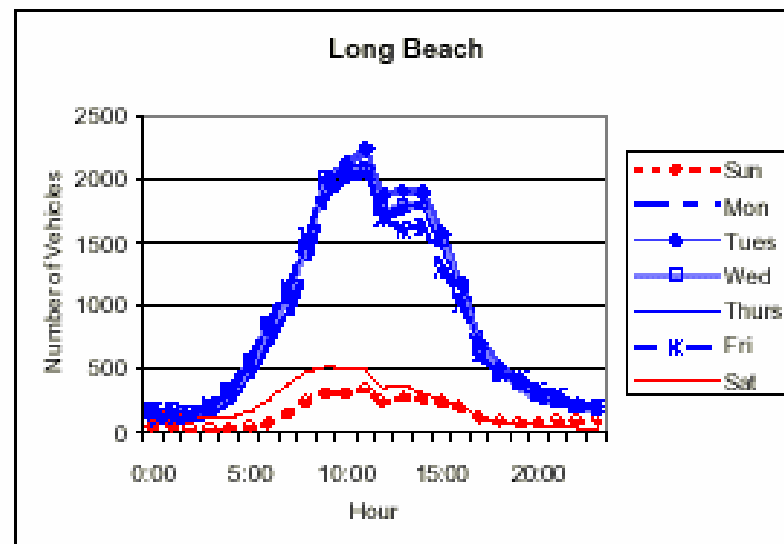
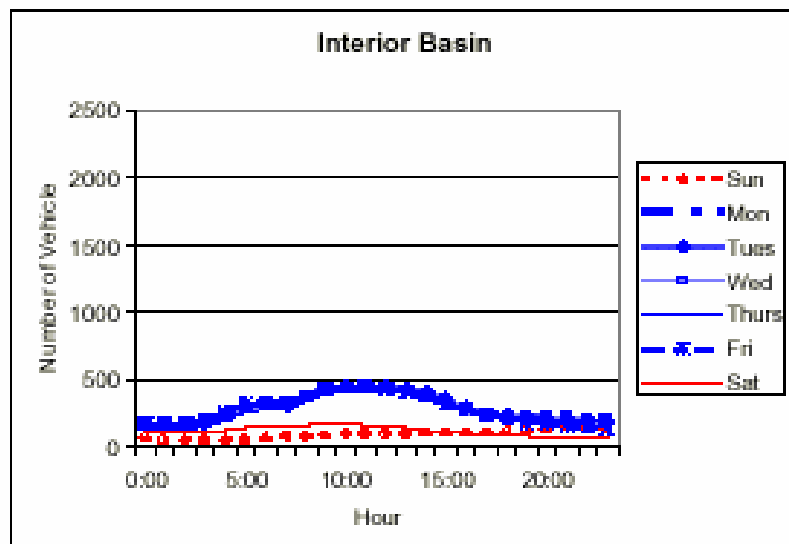
Hypotheses	Importance for Ozone Production	Confidence Level
Decreased weekend NOx emissions		
NOx emissions timing (NOx “boost”)		
Pollutant carryover near the ground		
Pollutant carryover from aloft		
Increased weekend VOC emissions		
Increased photolysis due to decreased PM		

EMISSION INVENTORY RESULTS

Light-Duty Vehicle Hourly Counts on Freeways



Heavy-Duty Vehicle Hourly Counts on Freeways



Weekday/Weekend Emission Inventory Differences

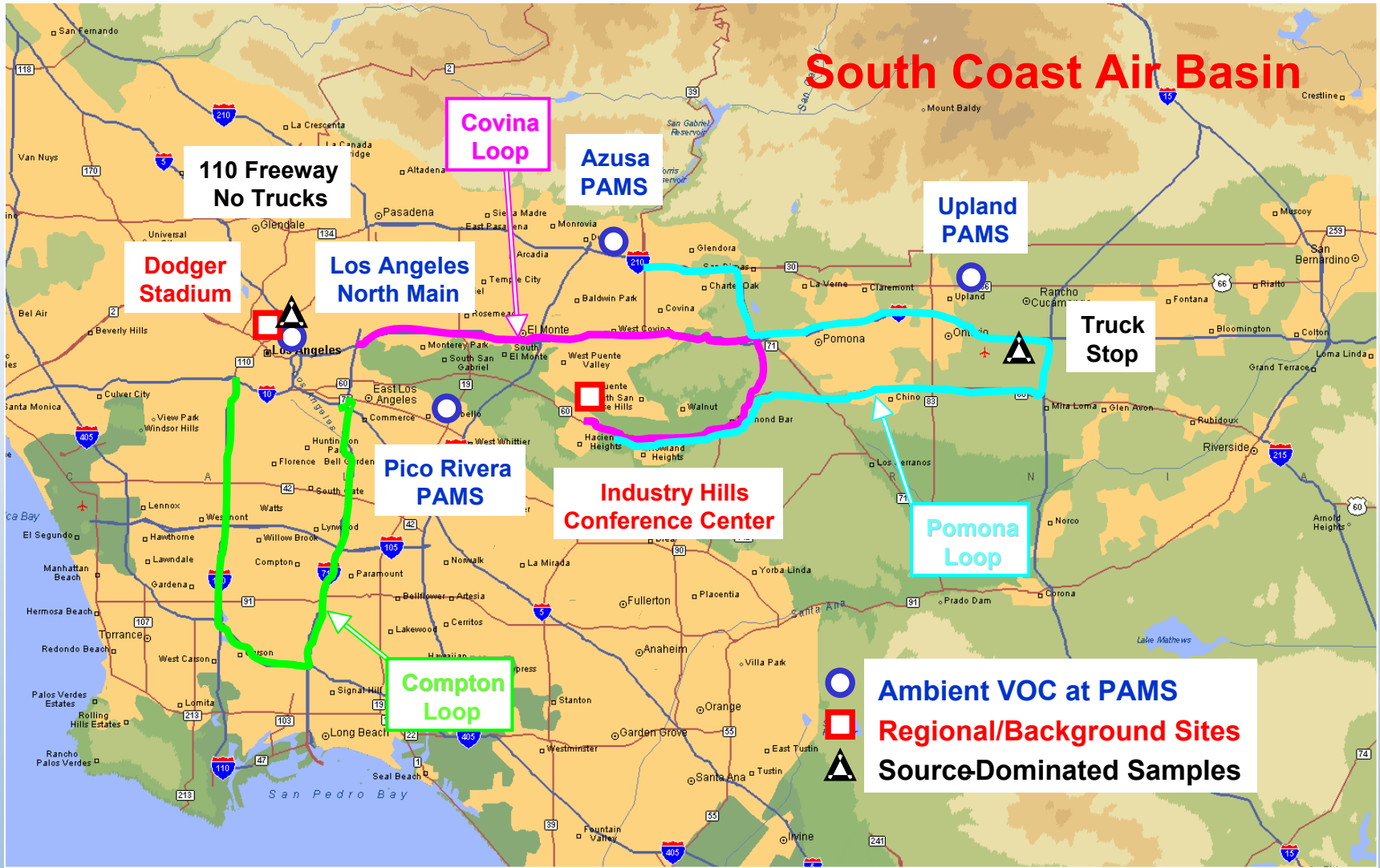
- Truck and bus freeway activity decreased by up to 80% on weekends
- 12-18% reduction in VOC emissions on Saturday and Sunday relative to weekdays
- 35-41% reduction in NO_x emissions on Saturday and Sunday relative to weekdays
- 30% increase in VOC/NO_x ratio on weekends relative to weekdays

FIELD STUDY

Ambient Measurements – Field Study

- Conducted Saturday, September 30 through Sunday, October 8, 2000
- Unique because this was an emissions-based study
- Ambient measurements made at routine AQMD and other fixed monitoring sites
- Mobile measurements made by sampling van at a variety of source locations and on various freeway loops

Sampling Locations During Field Study, September 30-October 8, 2000



Weekday/Weekend O₃ Study – Gasoline Source Profile Testing – 0647 hrs on Oct. 2, 2000



STUDY CONCLUSIONS

RESULTS OF HYPOTHESIS TESTING BY STUDY INVESTIGATORS

Hypotheses/Supported by Study	Importance for Ozone Formation	Confidence Level
Decreased weekend NOx emissions – YES	Significant	High
NOx timing (NOx “boost”) – NO	Insignificant	High
Pollutant carryover near the ground – YES	Small	High
Pollutant carryover from aloft – NO	Insignificant	Medium
Increased weekend VOC emissions – NO	Small to Insignificant	Medium
Increased photolysis due to decreased PM – NO	Small to Insignificant	Medium

Supported by Study Results = **Yes**

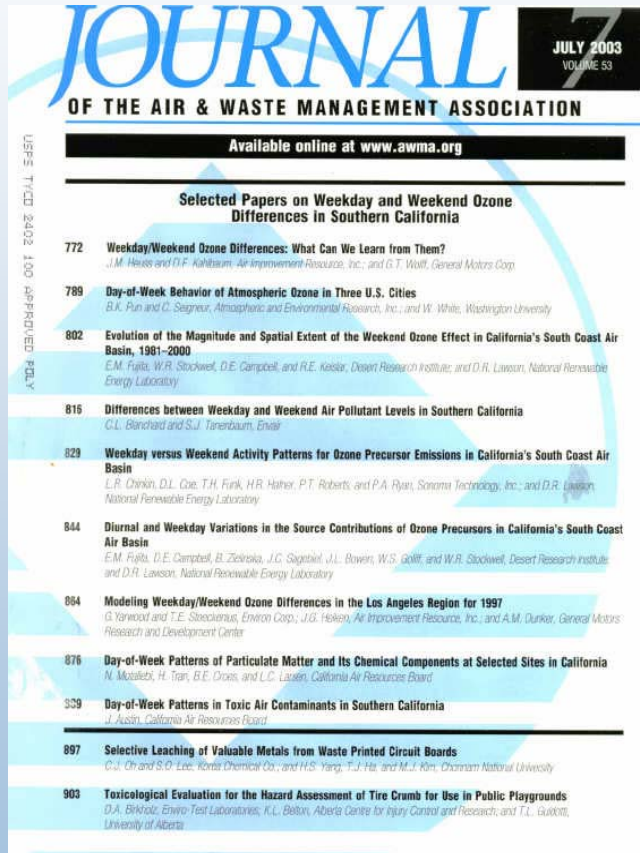
Not Supported by Study Results = **No**

Conclusions

- NOx reductions in Southern California increase ambient ozone levels. This NOx reduction comes mostly from fewer trucks on the road on weekends.
- Ozone reductions in the SoCAB since 1987 are mostly due to VOC, and not NOx, emission reductions.
- At current VOC levels, NOx emission reductions as large as 80-90% will be needed before the NOx disbenefit can be overcome.
- Emission projections for 2010 suggest that ambient weekday ozone levels in the SoCAB may be as high as today's weekend ozone levels unless drastic changes in control strategies are enacted.

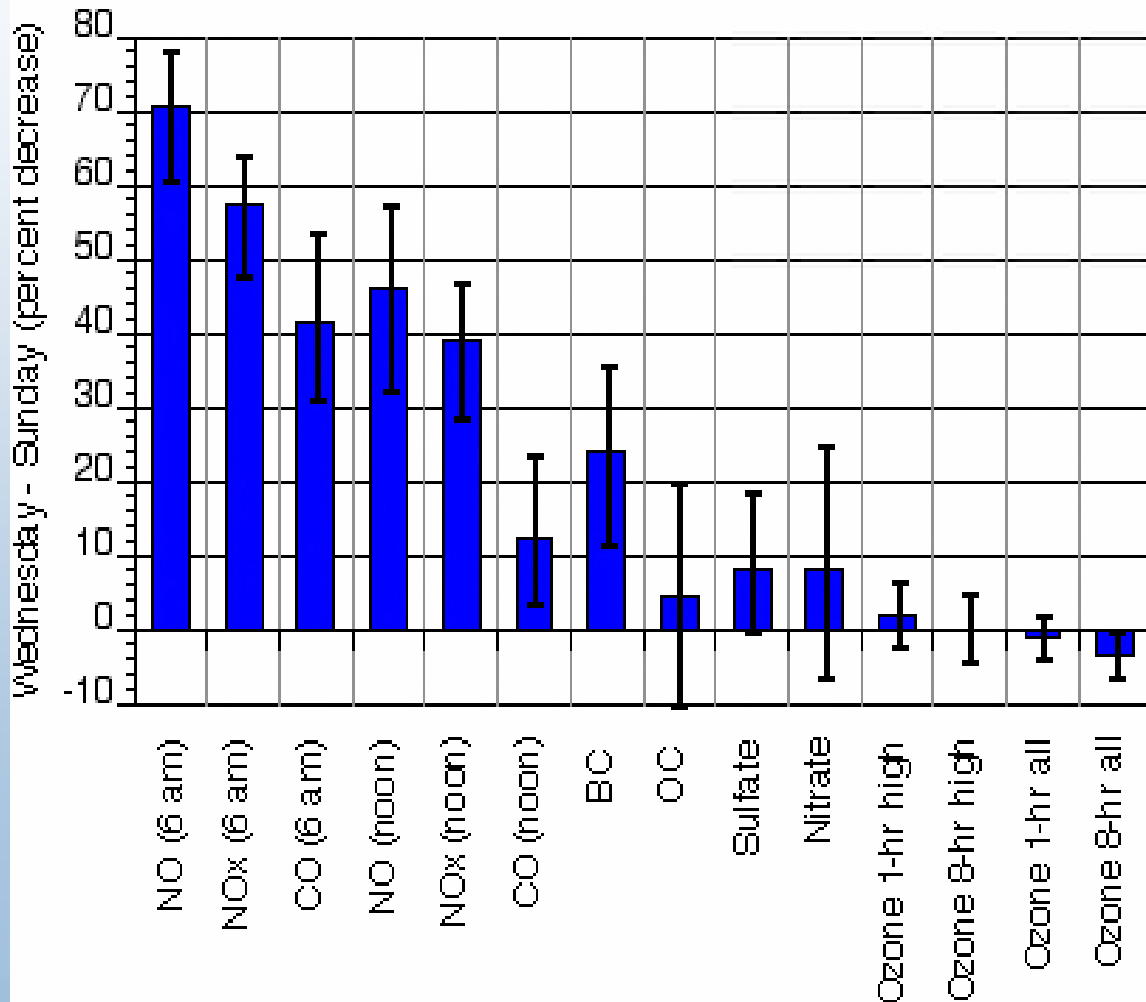
Peer-Reviewed Publications

July 2003



CURRENT WORK

Wednesday/Sunday Pollutant Differences Nationwide Ambient Monitoring Data, 1998-2002/3

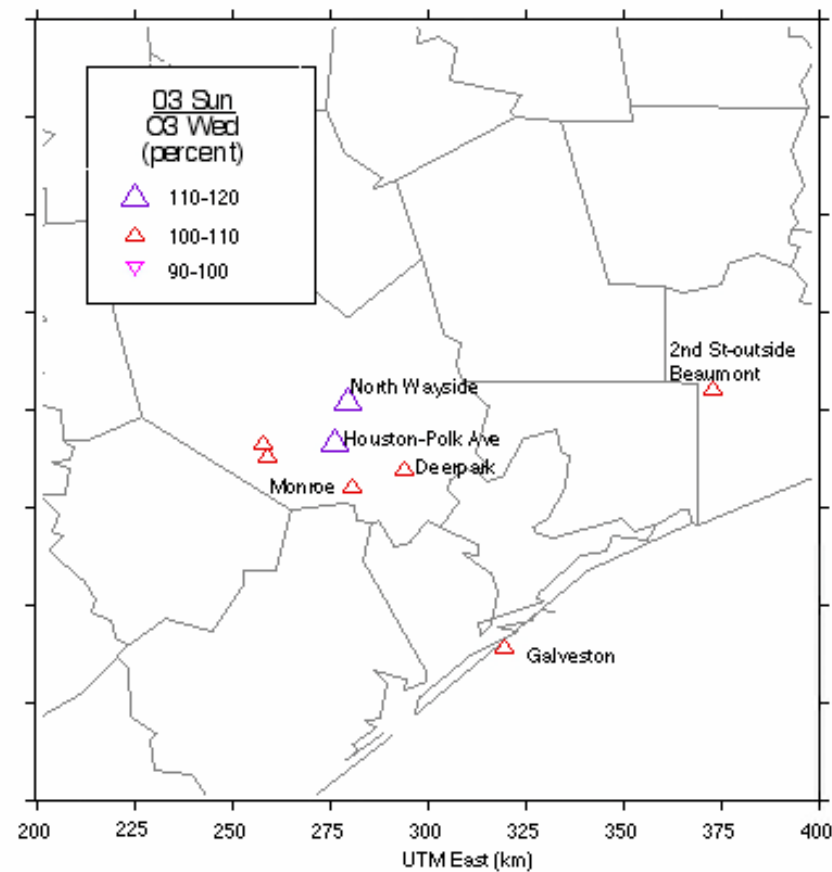
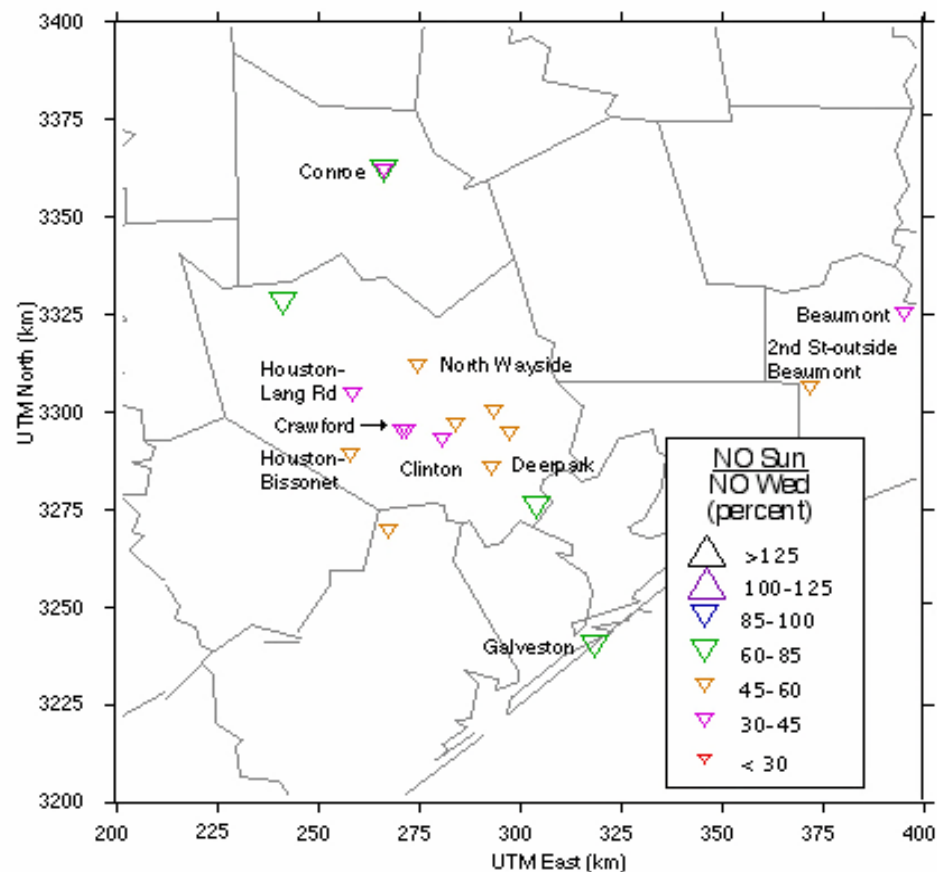


~475 O₃ sites

~175 NO sites

New England states,
Mid-Atlantic states,
Lake Michigan area,
Atlanta, Houston/
S.E. LA, DFW, Denver,
Phoenix

Houston Area Sunday/Wednesday NO and O₃ Ratios



Acknowledgments

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Participants/Technical/Logistical Assistance

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- California Air Resources Board
- Caltrans
- Desert Research Institute
- Envair
- ENVIRON
- Freeman, Sullivan, Inc.
- Sonoma Technology, Inc.
- South Coast Air Quality Management District
- Wiltech

Mean Wednesday
± 1 sigma

Mean Sunday
± 1 sigma

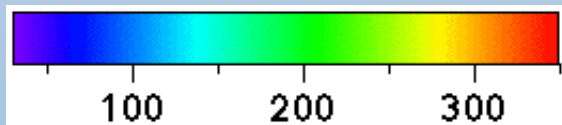
Monitoring Stations

A – Azusa

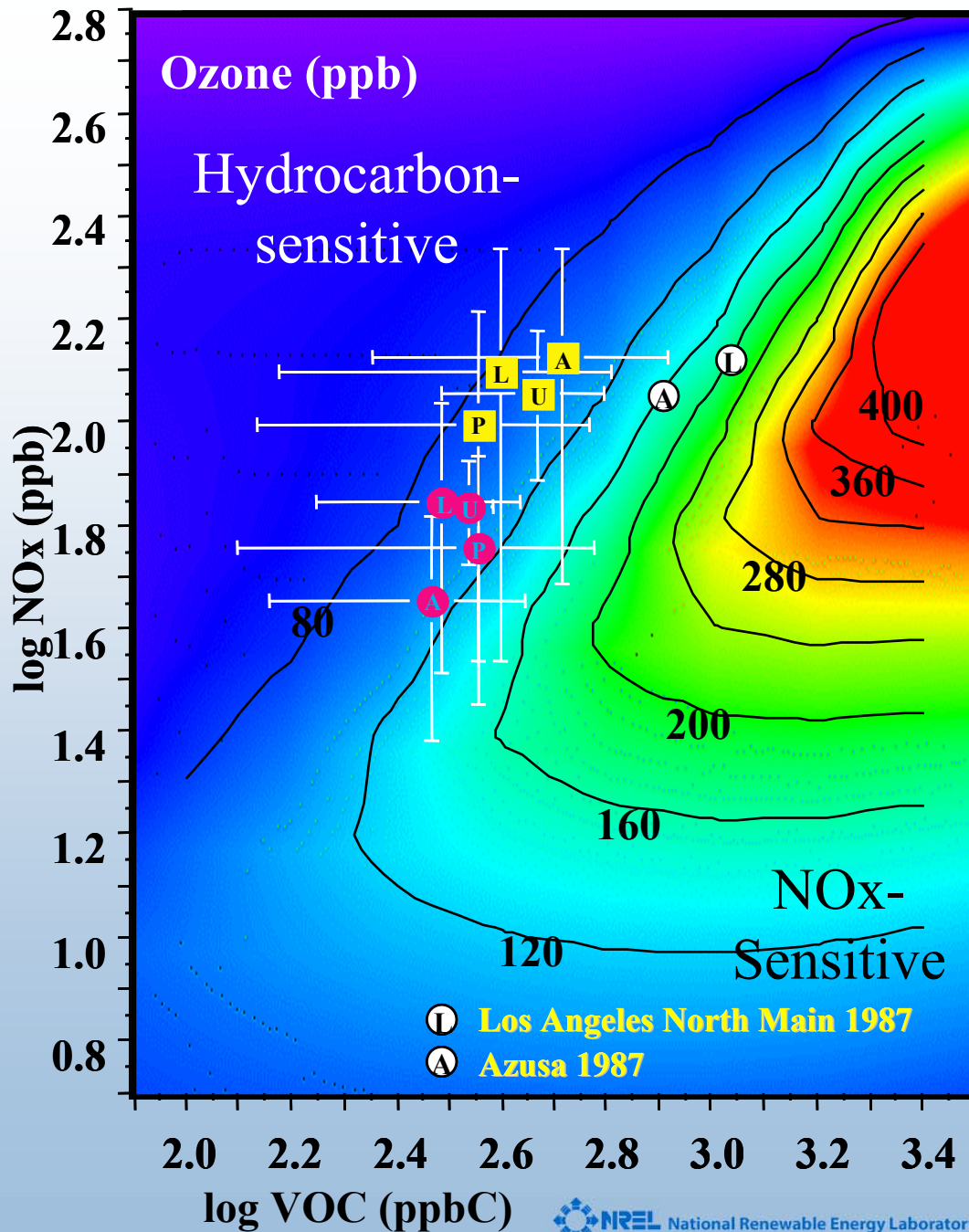
L – Los Angeles, N. Main

P – Pico Rivera

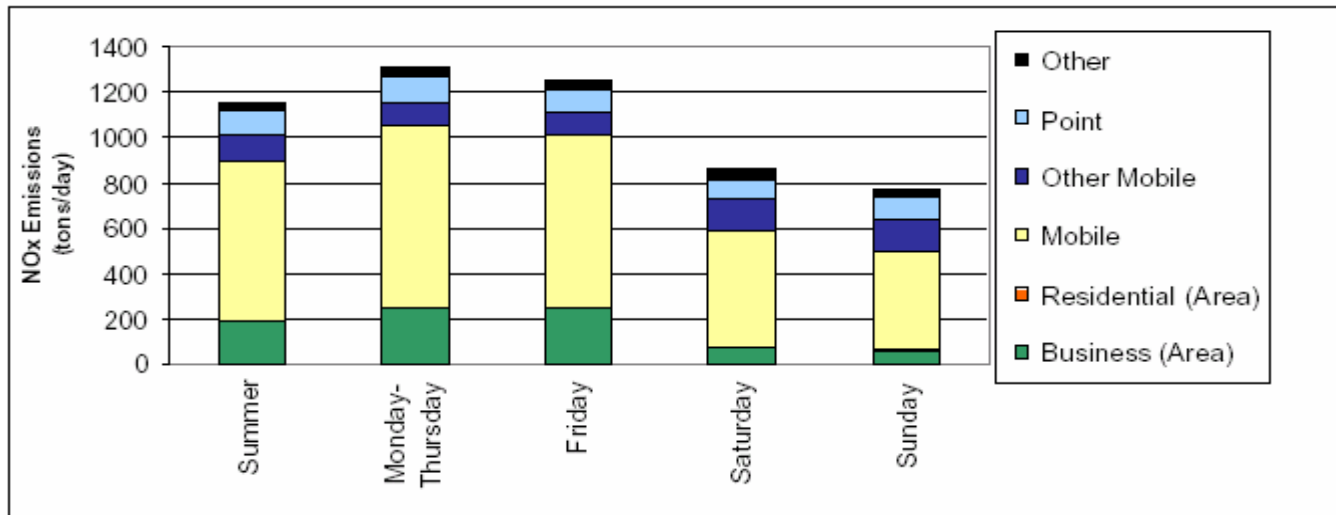
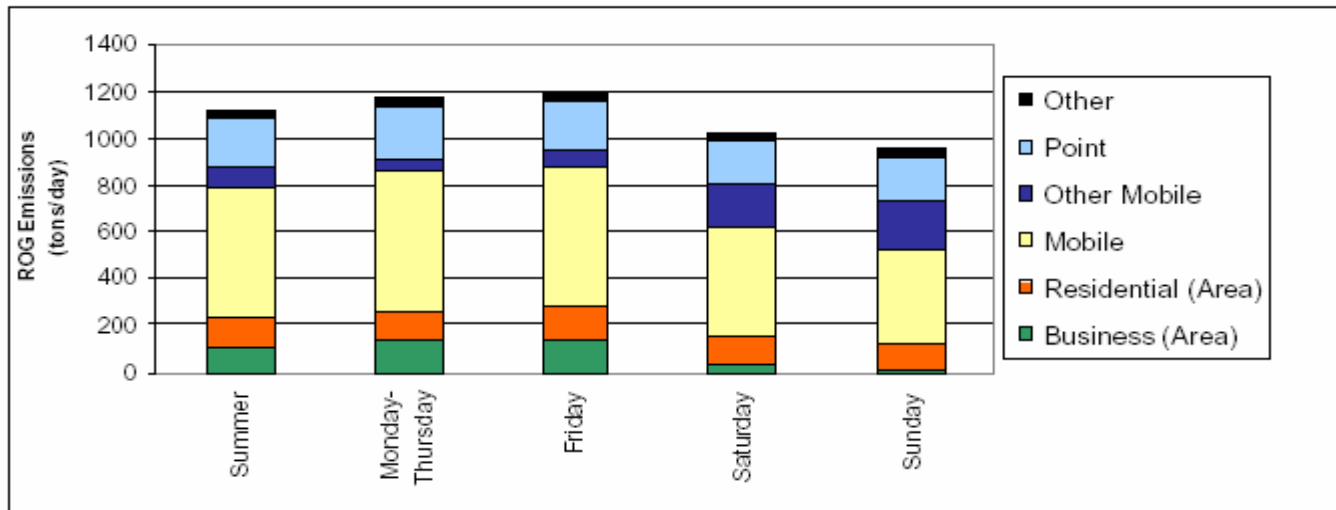
U – Upland



Ozone (ppb)



Estimated Day-of-Week Emission Inventory



OZONE TRENDS IN THE SOUTH COAST AIR BASIN

“Forecasting is difficult, especially when it involves the future.” – Casey Stengel

