

Urban Pollution Control Strategies

Reading:

Review pages 31-55

Health effects of particulate matter – 5.4.3, p162-166

Health effects of HCs – 5.4.4, p166-167

Health effects of NO_x – 5.4.5, p167-168

Health effects of ozone – 5.4.6, p169-170

Federal Monitoring Requirements – 7.1.3, p229-230

Air Quality Monitoring Networks – 7.1.3.1, p230-231

Air Quality Index – 7.1.3.5, p239-240

Regulation and Public Policy – 8.1, p257-259

Regulatory Strategies and Tactics – 8.2, p259-265

Federal Legislative History – 8.3, p265-267

Air Pollution Control 1970-1990 – 8.4, p268-287 (skim this)

Urban Pollution Control Strategies

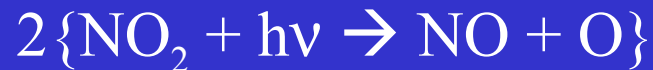
What we know so far:

- Different regions have different issues, but two types of ‘smog’ stand out
 - London-type (cold, damp, smoke, fog, sulfur)
 - Los Angeles-type (photochemical) (sunny, warm, NO_x, HCs, ozone, CO)
- Pollution is made worse by meteorological conditions called “inversions”
- In all cases, it’s important to *reduce emissions*, but in the case of the photochemical pollution, there are primary and secondary pollutants to be concerned with – e.g. ozone. One doesn’t ‘reduce emissions’ of these secondary pollutants. Rather, one identifies the mechanism of formation and goes after the primary pollutants that are responsible for the formation of the secondary pollutants.

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What we know so far:

- Generic scheme for photochemical smog:



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What we know so far:

Primary pollutants: NO, hydrocarbons (RH), CO

Secondary pollutants: NO₂, R'CHO (HCs), O₃

HC = hydrocarbon

VOC = volatile organic compound

We typically call species that appear on both sides of a series of reactions “intermediates”, although we call those intermediates that speed up the overall reaction scheme “catalysts”.

We know that the catalyst OH is formed by the reaction of H₂O with O(¹D) (which comes from ozone photolysis)

Let's examine the evolution of photochemical smog on a typical day in Los Angeles

Early morning (6 – 9 am): Automobile traffic and industrial emissions begin. Largest concentrated emissions of CO, RH, and NO. Winds generally slack and air is relatively stagnant, with a low inversion layer.

Midday (9 am – 2 pm): Primary emissions continue. Photochemical transformations take place. Sea breeze picks up and transports pollutants inland. Maximum sun intensity around noon.

Late afternoon (3 – 5 pm): Ozone concentrations peak. Inversion usually broken, so vertical transport moves pollutants upward and sometimes out of region.

Evening (5 – 7 pm): More primary emissions from traffic. Low sun angles, so difficult to make secondary pollutants. Primary pollutants can accumulate. Ozone concentrations begin to fall.

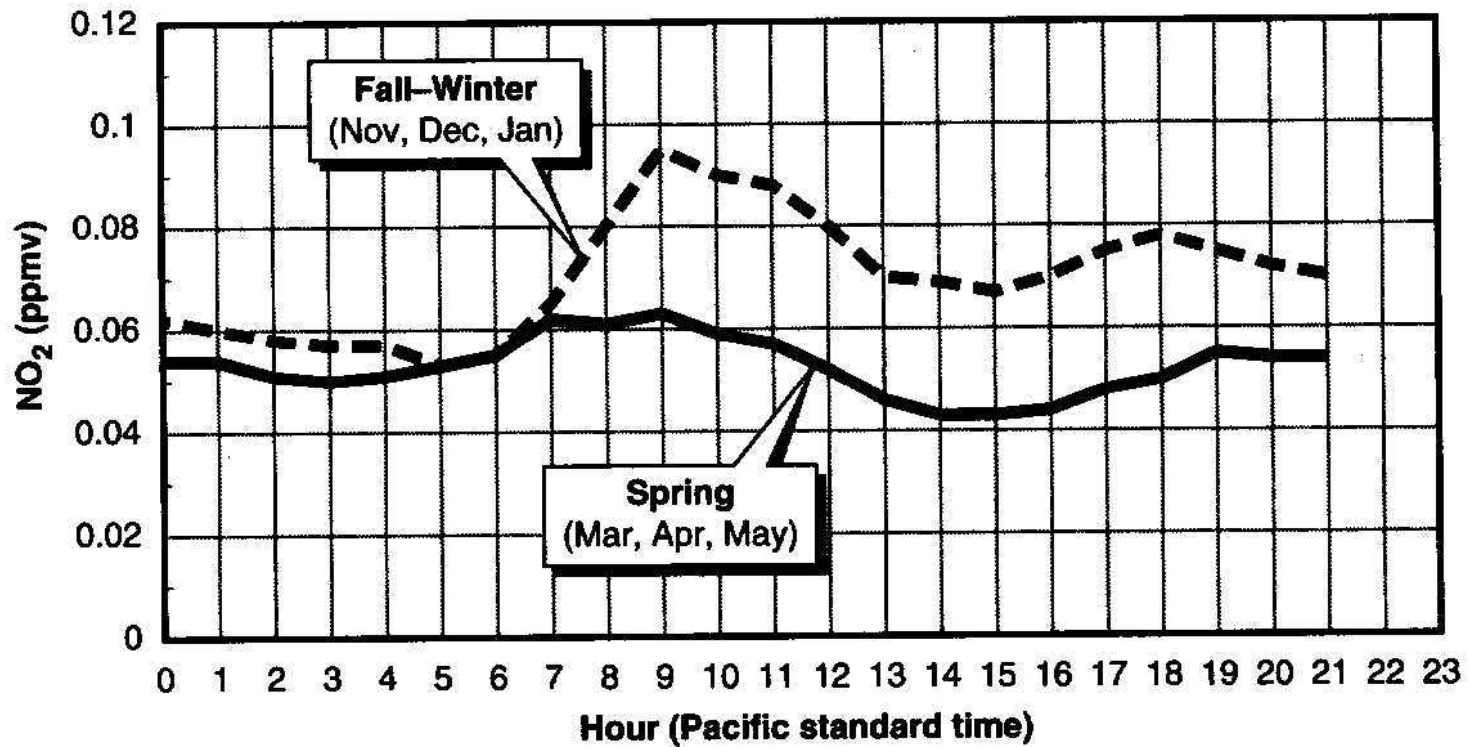
Late evening (7 – 9 pm): Sea breeze dies. Temperature inversion reforms, usually leaving day's pollution above (accounts for layered structure of multiple day's smog).

Overnight (9 pm – 6 am): Pollutants are converted to reservoir species, such as HNO_3 and peroxy acetyl nitrate (PAN = $\text{CH}_3\text{C}(\text{O})\text{O}_2\text{NO}_2$).

Species like PAN can be very toxic, so regulations are often established to reduce their buildup in urban regions

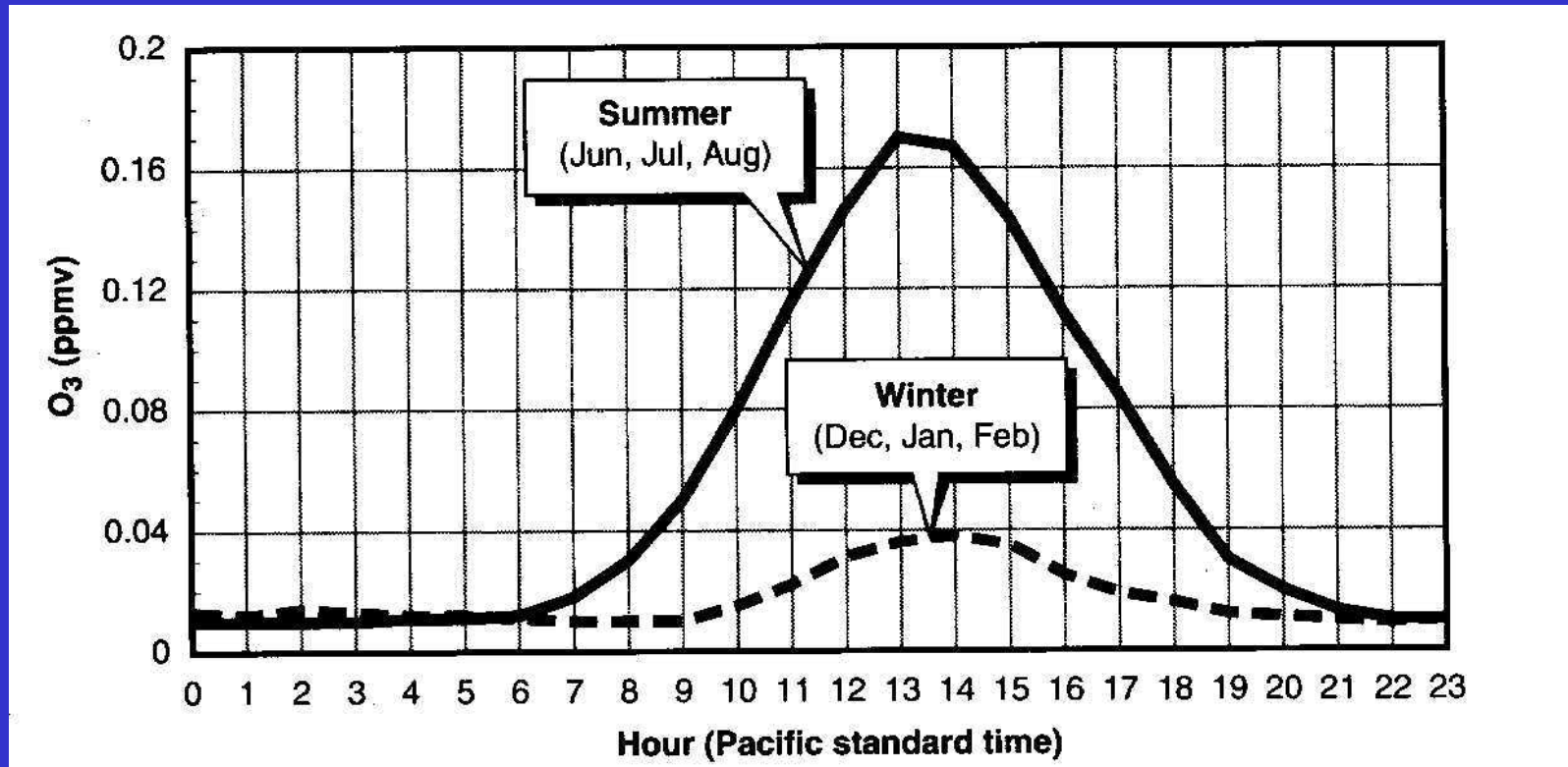
Diurnal Behavior of Various Species

Nitrogen dioxide (NO₂)



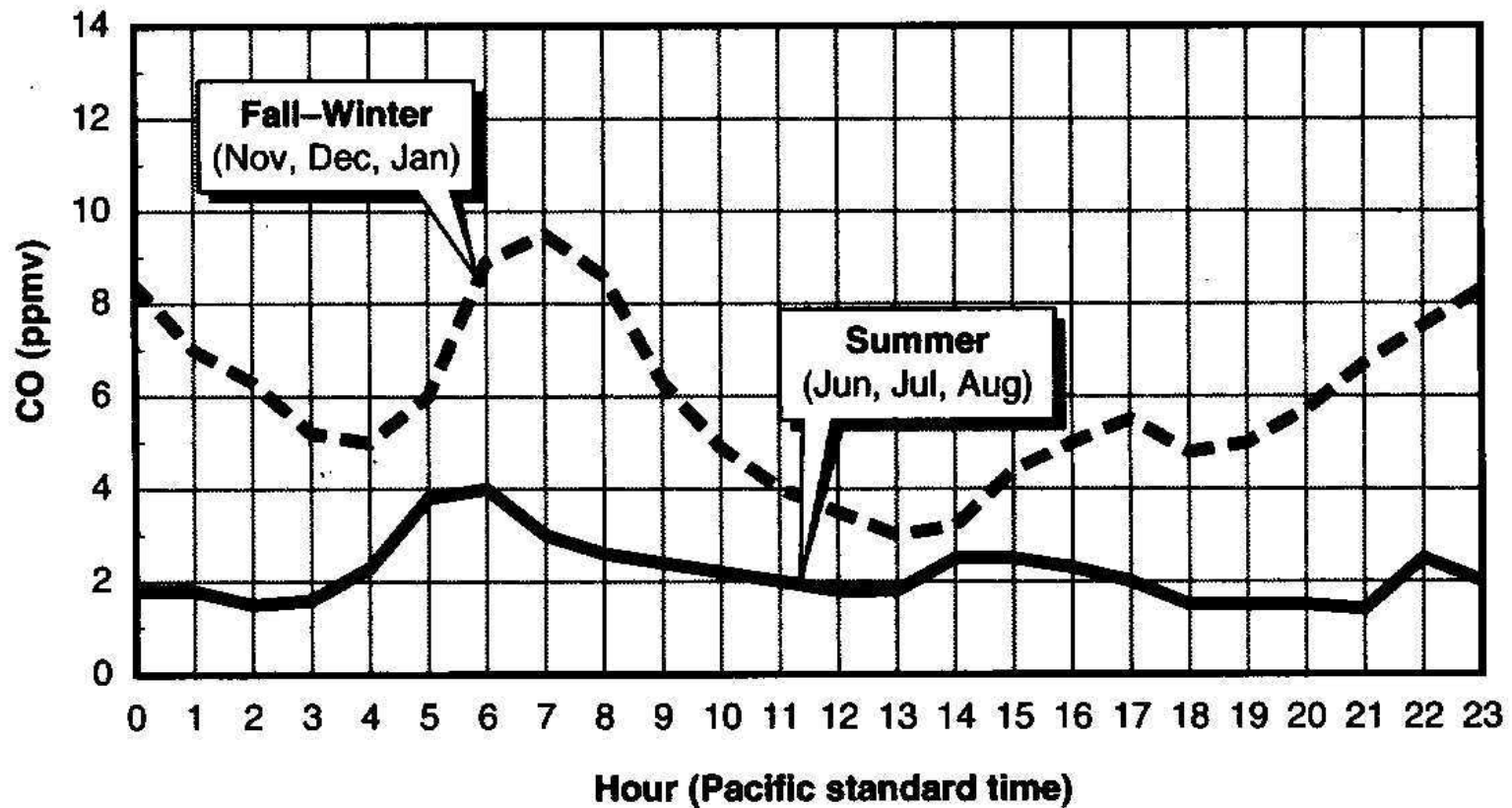
Diurnal Behavior of Various Species

Ozone (O_3)



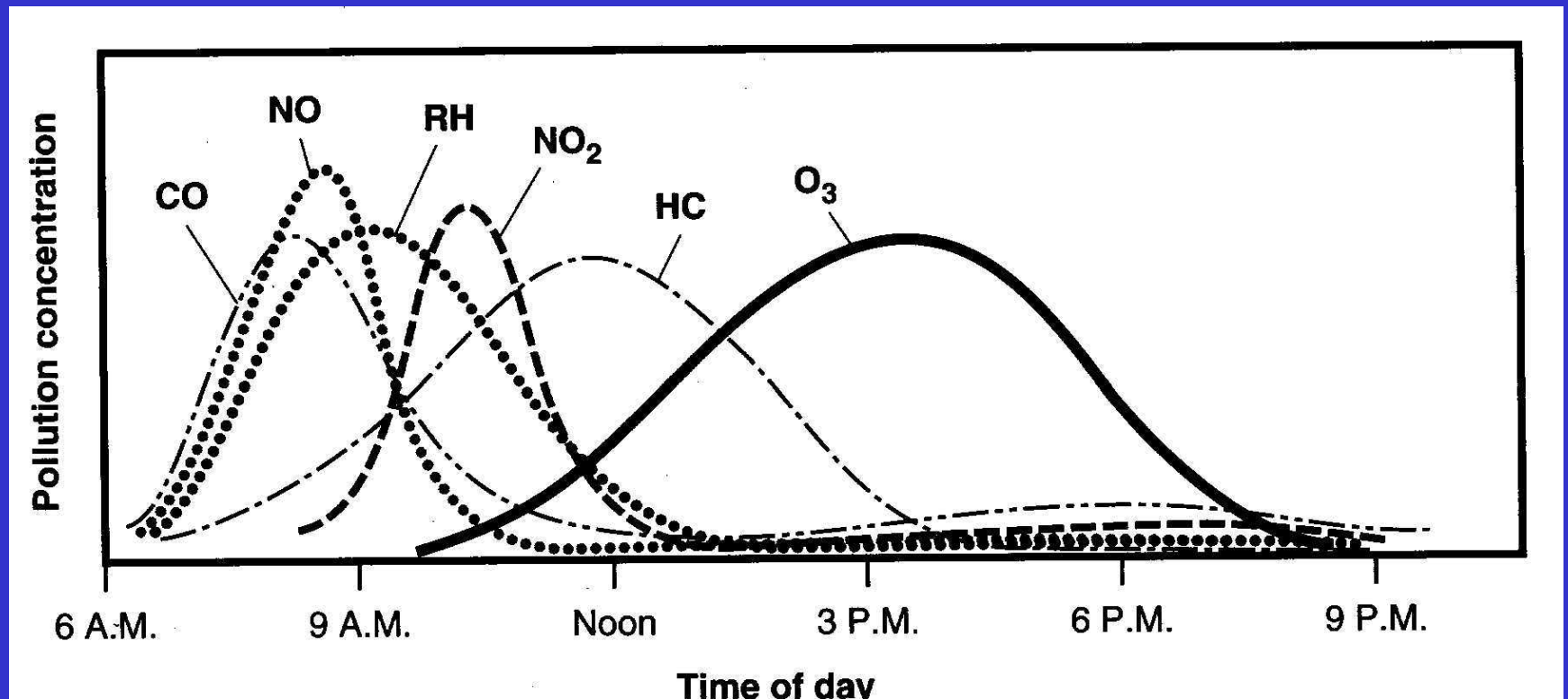
Diurnal Behavior of Various Species

Carbon Monoxide (CO)



Diurnal Behavior of Various Species

Putting it all together:

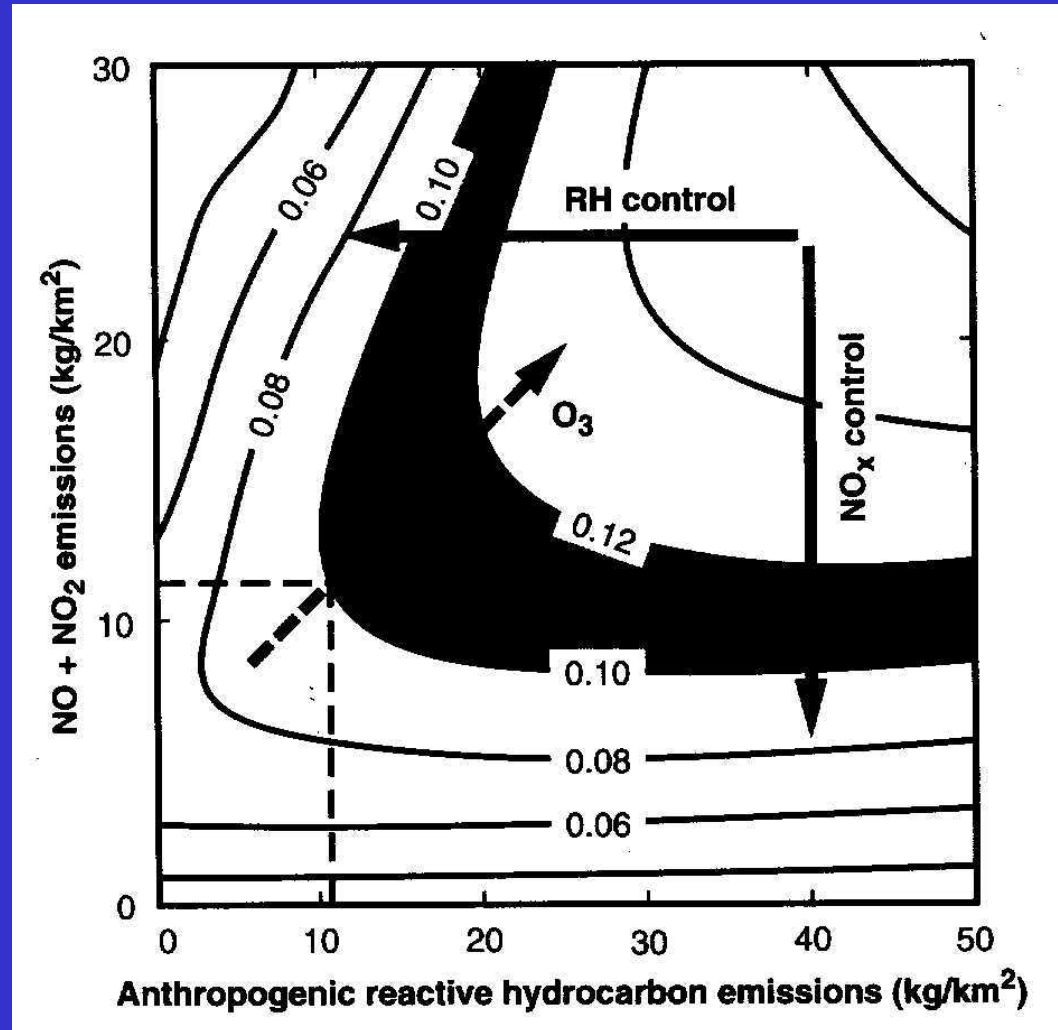


Controlling Smog

Requires a combination of RH and NO_x controls

In regions with relatively high VOCs (e.g. near forests), reductions in NO_x are effective in reducing O_3 .

In regions of low VOCs, reducing NO_x can actually increase ozone (although this isn't necessarily a bad thing because it could reduce products like PAN!).



Unlike acid rain, can't really fix or forestall damage once pollutants are emitted. Instead, need to control emissions (sources)

Culprit #1: Old cars ("heaps" or "junks")

- emit much more than newer cars
- 10%/90% issue
- identifying worst polluters?

Culprit #2: Industry

- concept of waivers or allowances
- advantage of always reducing pollution
- does it send a bad message?

Culprit #3: Energy usage

- alternative fuels
- population; lifestyles