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## **The Weekend Effect: The Science Suggests that we are Embarking on an Expensive Policy Which Will Harm the Environment {presentation}**

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# The Weekend Effect: the science suggests that we are embarking on an expensive policy which will harm the environment

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# What is the weekend effect

We know that photochemical ozone arises from emissions of hydrocarbons (HC) and oxides of nitrogen [(NO<sub>x</sub>) today mostly emitted as NO] in combination with sunlight. Every weekend there is a reduction in HC emissions (less miles driven) and a larger reduction in NO<sub>x</sub> emissions. These emissions reductions surely should cause ozone (O<sub>3</sub>) to go down. In many places ozone either goes up or remains at the same level as weekdays. In both cases this is an observation of the weekend effect.

My recommendation is that the 2010 mandatory NO<sub>x</sub> emissions reductions should be postponed until the inevitable HC emissions reductions bring ozone so far into compliance that the disbenefits of NO<sub>x</sub> reduction will be unimportant.

# History of the weekend effect

Elkus and Wilson, (1977) in “Photochemical Air Pollution: Weekend-Weekday Differences” stated:

*In fact, we find that for most of the year the average weekend oxidant concentration is higher than the corresponding weekday value, despite the lowered emissions*

Calvert and McQuigg (1975) demonstrated, using a computer model, that increasing NO<sub>x</sub> input decreased ozone formation. The conclusion, quoted from NRC (1977) was:

*These data do not mean that unrestricted emissions of NO<sub>x</sub> would solve the smog problem; however, they do imply that smog formation would be delayed. At some point downwind, the turbulent mixing will cause a reduction in the NO<sub>x</sub> level that will be loaded for smog formation.*

# Reason for the weekend effect

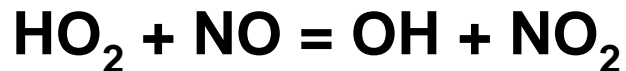
## Photostationary State



$$d\text{NO}/dt \sim 0$$

$$d[\text{NO}]/dt = j(1)*[\text{NO}_2] - k(3)*[\text{O}_3]*[\text{NO}]$$

$$[\text{O}_3] = j(1)*[\text{NO}_2]/k(3)[\text{NO}]$$



# The breakthrough in understanding the photochemistry comes from:

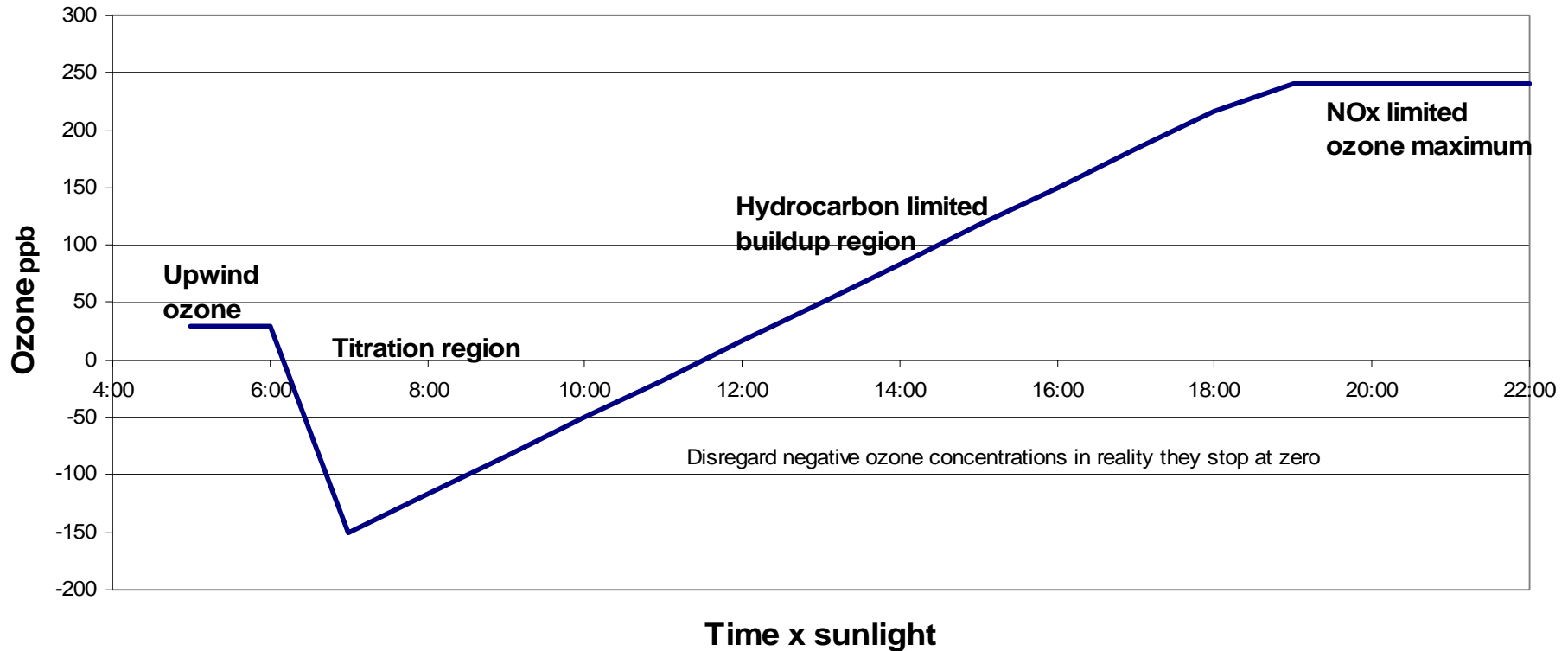
G.M. Johnson (“A simple model for predicting the ozone concentration of ambient air”. Proc. 8th International Clean Air Conference pp 715-731, H.F. Hartmann et al eds. 1984).

**When time and sunshine are combined on the x-axis, the rate of ozone formation is proportional only to the HC concentration and reactivity**

**The amount of ozone removed when the NO is emitted and formed when the HC runs out (if the sunshine remains) is proportional only to the NO<sub>x</sub> emissions.**

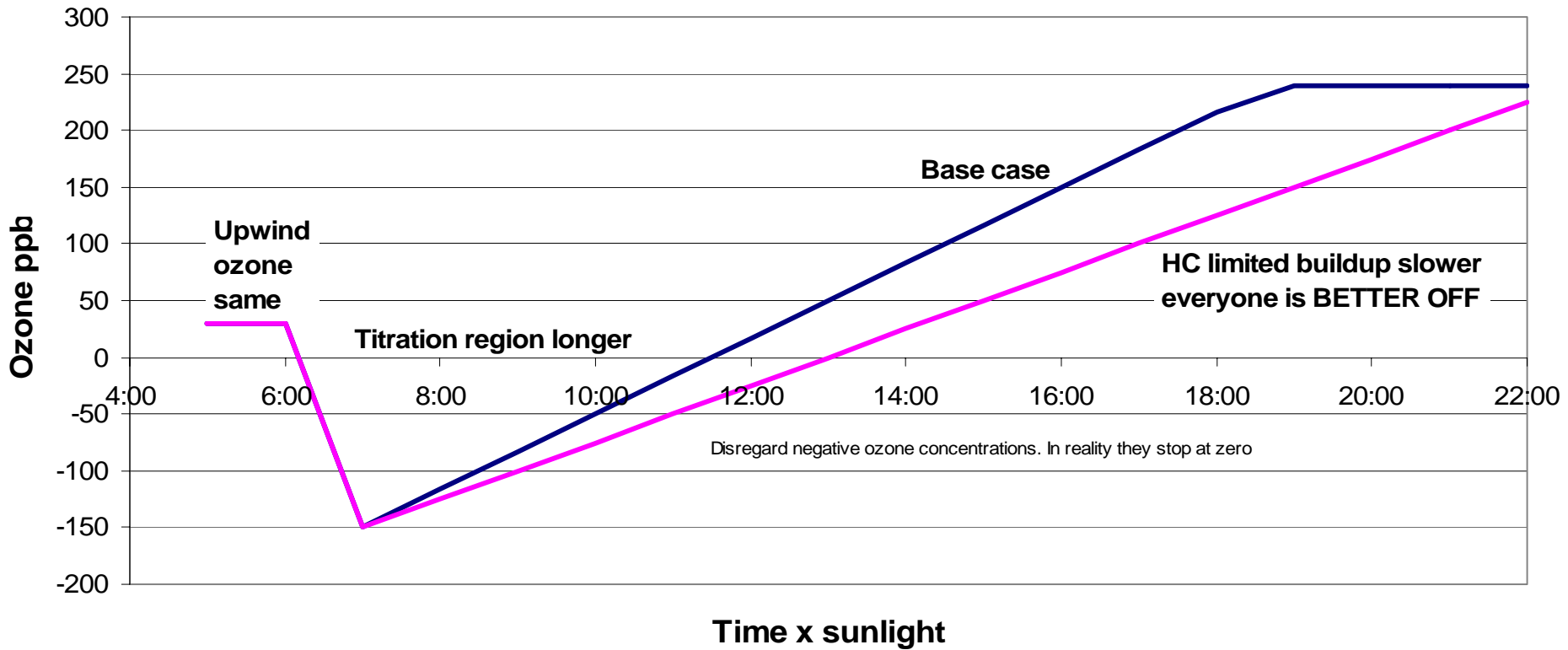
# Ozone as a function of time in Los Angeles

## Simplified ozone model



# The benefits of HC reduction

## Simplified model 25% HC reduction only

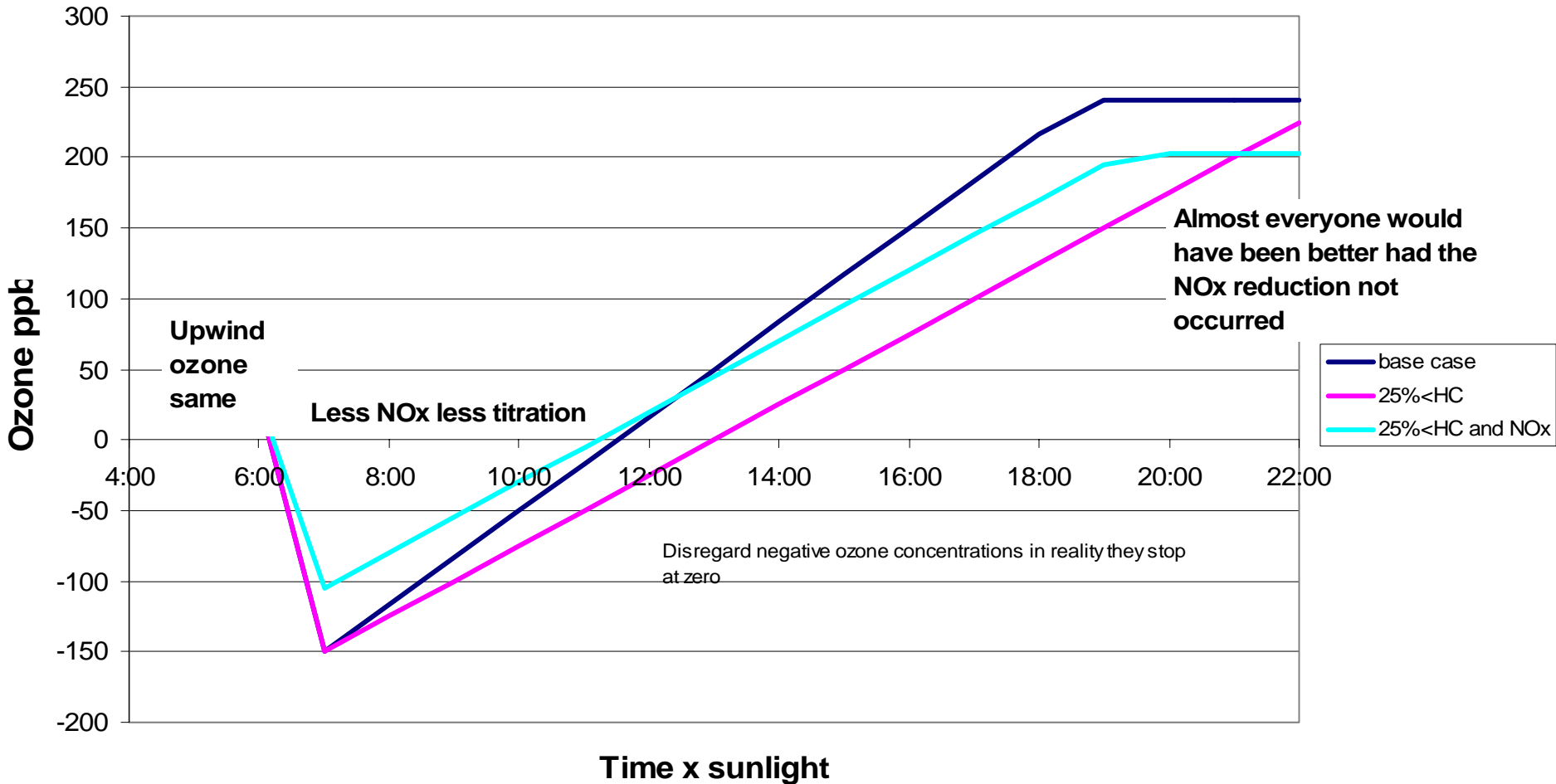




# The disbenefits of NOx Reductions

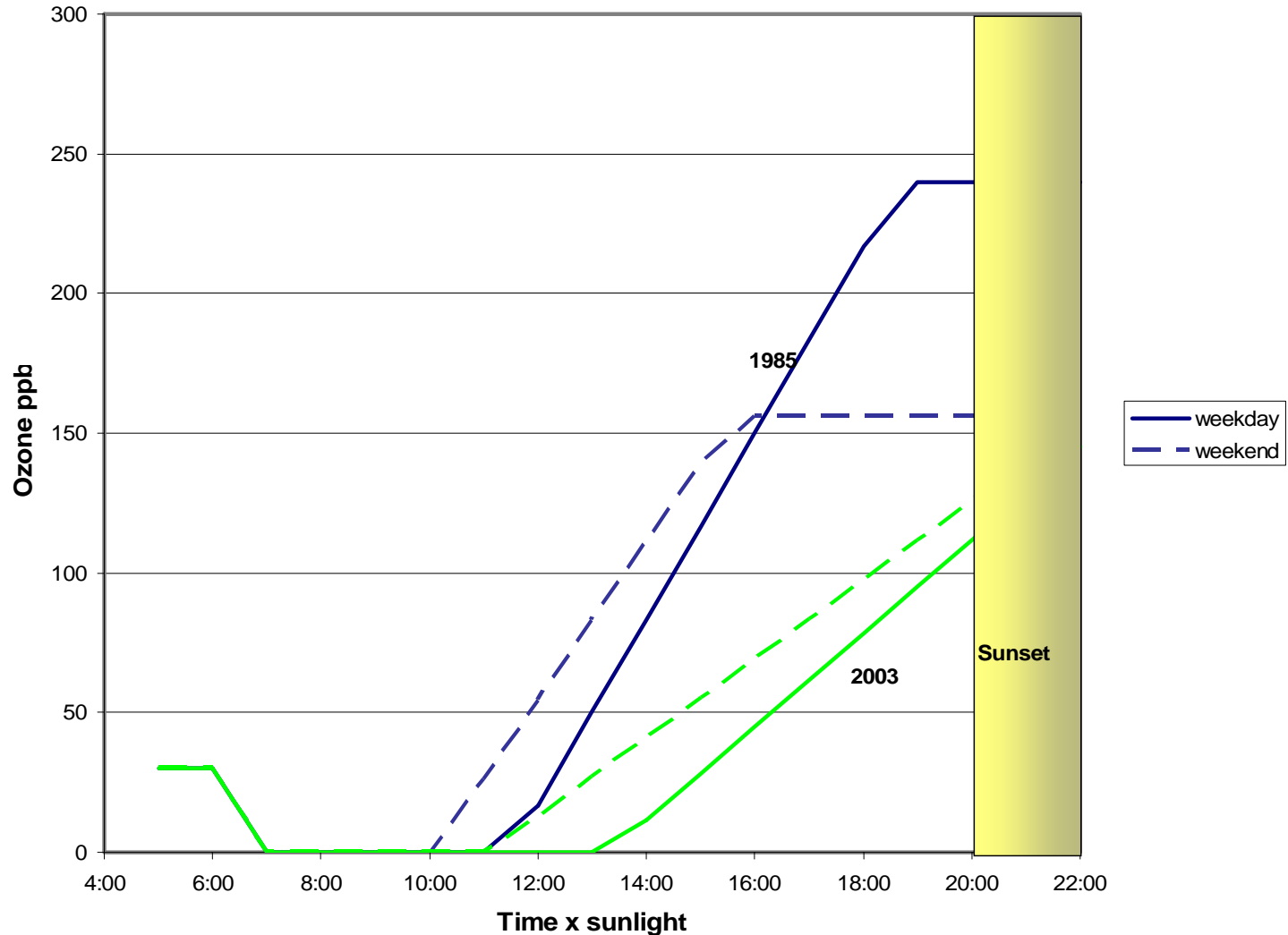
## *Most people are worse off*

Simplified model HC and NOx reduction



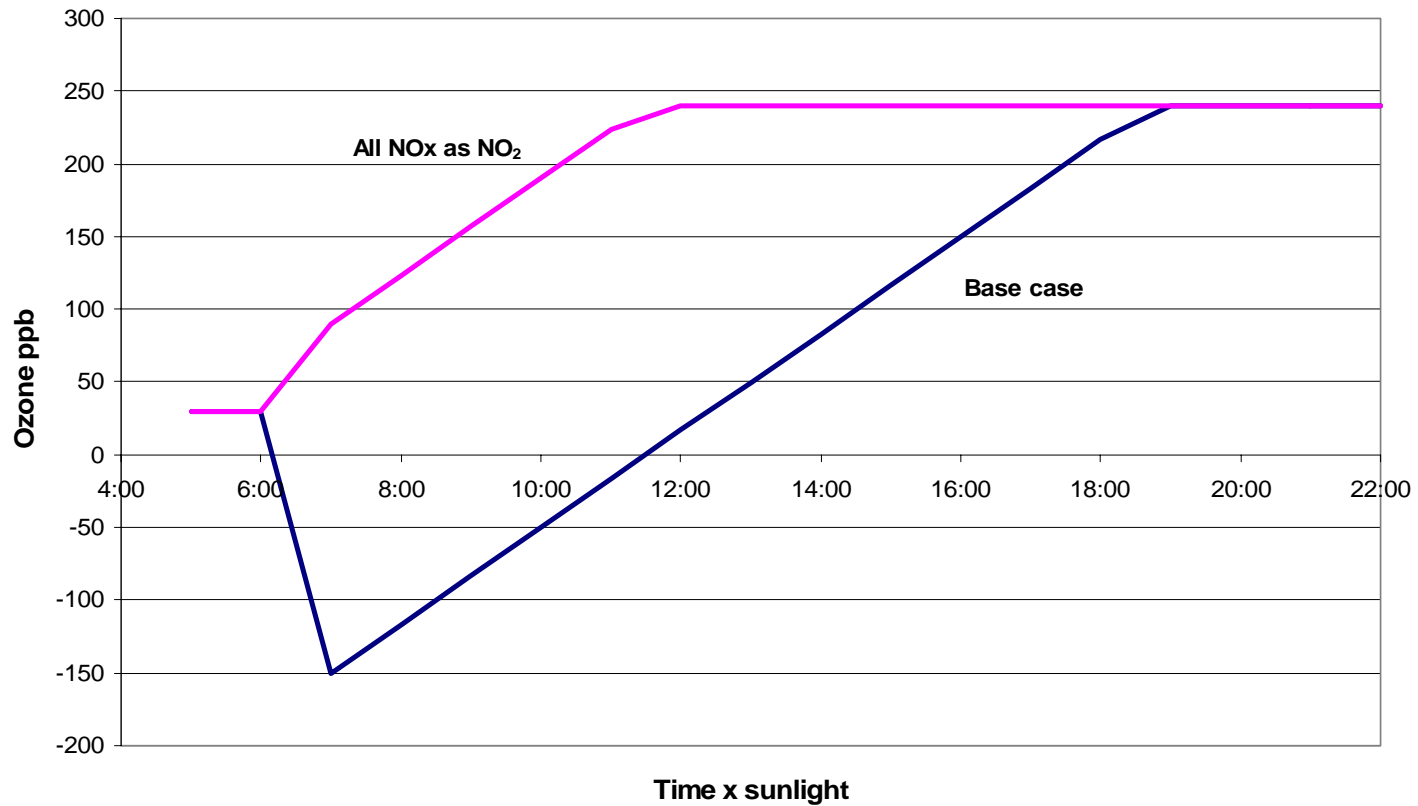
# Most everyone breathes higher weekend ozone now and in 2010 it will be worse

Simplified Model Weekend Effect 1985 and 2003



# If NO<sub>x</sub> is emitted as NO<sub>2</sub> very bad things happen

Simplified model with all NO<sub>x</sub> emission as NO<sub>2</sub>



# Summary and Conclusions

- Hydrocarbon reductions lead to a slower ozone buildup which is better for everyone.
- NO<sub>x</sub> reductions lessen the benefits of hydrocarbon reductions and most people are worse off.
- Most everyone breathes higher weekend ozone now and in 2010 ozone levels will be worse.
- **The science suggests that current NO<sub>x</sub> reduction policies will harm the environment**