



## Emissions Down, Smog Up. Say What?

By Joel Schwartz and Steven F. Hayward

*On the surface, the effort to reduce ozone levels seems to have stalled, as ozone levels have flattened or increased recently in some areas. However, a closer look at the data reveals a counterintuitive anomaly: high ozone levels are increasingly found to be occurring on weekends, when emissions of nitrogen oxides, an ozone precursor, are often 40 percent lower than weekdays. What explains higher ozone levels with lower emissions? Does current regulatory policy take into account this anomaly, or do we need to reconsider our smog-fighting strategy?*

Was 2003 the year we started losing the battle against ozone smog? That is what you would think if you read the media headlines. “Smog Woes Back on Horizon,” trumpeted an above-the-fold *Los Angeles Times* headline in mid-July.<sup>1</sup> “It’s One Smoggy Summer,” declared the Associated Press. And *USA Today* joined the chorus in October with “Smoggy Skies Persist Despite Decade of Work.”<sup>2</sup>

Unfortunately, a reader of these articles will learn very little about what is behind the recent uptick in ozone levels. To the contrary, most media stories convey loads of misinformation. The *USA Today* story, for example, offers this explanation of stubborn ozone levels: “One likely reason why the smog isn’t lifting: Americans are driving more miles than they did in the 1980s. And they’re driving vehicles that give off more pollution than the cars they drove in the ’80s” (emphasis added). *USA Today* needs a better fact-checking department. Late-model cars and light trucks (including SUVs) are much less polluting than models sold in the mid- and late-1980s. Even

with increased miles driven, total nitrogen oxides (NO<sub>x</sub>) emissions from cars are down 56 percent since 1985 according to the most recent EPA data, and emissions of volatile organic compounds (VOCs) from cars are down a whopping 67 percent. As shown in figure 1 below, SUVs have had about the same VOC emissions as cars since the 1996 model-year, while the NO<sub>x</sub> difference disappeared with the 2001 model-year.<sup>3</sup> On-road measurements around the country show that average vehicle emissions are dropping about 10 percent per year as the fleet turns over to inherently cleaner vehicles, including modern SUVs.<sup>4</sup> But total driving is increasing only about 1 to 3 percent each year, giving net annual emissions declines of about 7 to 9 percent. Figure 2 shows rapid, net declines in vehicle emissions, even after accounting for growth in SUVs and driving.<sup>5</sup> *USA Today*’s reporting on automobile emissions is not merely wrong, but represents the polar opposite of reality.

Nor will you learn much about the whole story from the environmental lobbies, who are no doubt getting ready to say, “I told you so!” Having complained that President Bush’s changes to New Source Review (NSR) would increase pollution, the uptick in ozone in some areas looks like vindication. In fact, the changes to NSR have nothing to do with the recent trends in ozone.<sup>6</sup> A large story is being surprisingly overlooked, one that

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Figure 1: Car and Light Truck Emissions by Model Year

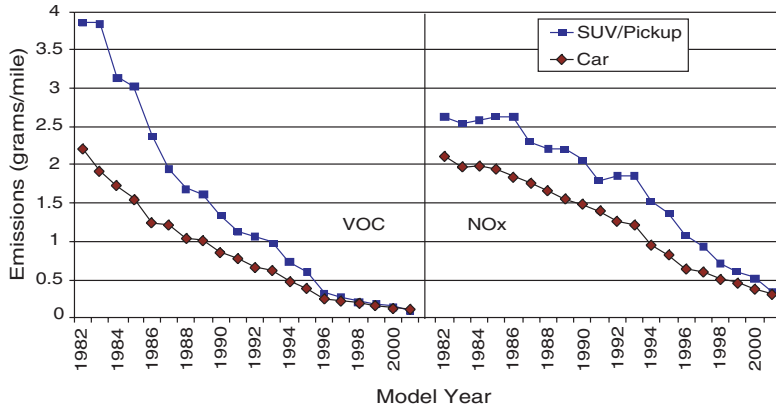
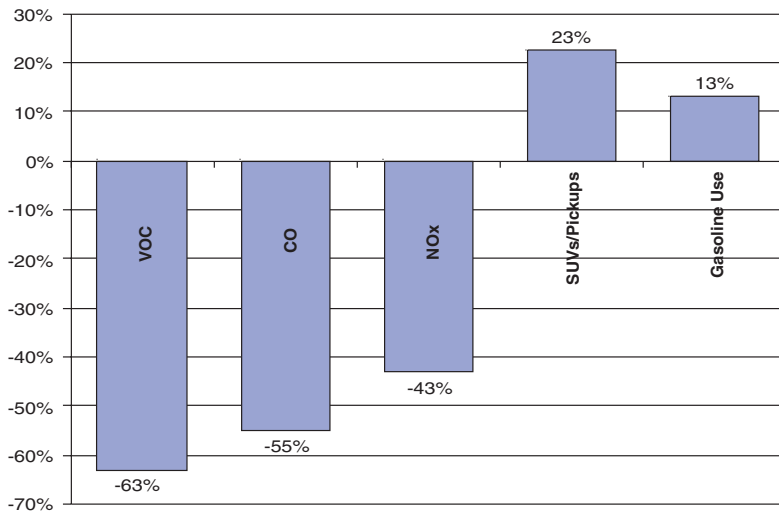


Figure 2: Net Change in Automobile Emissions in California, 1994–2001



can be posed in the following general question: if emissions of ozone precursors from cars and other sources are falling so fast, why are ambient levels of ozone not falling as well?

### The “Weekend Effect”

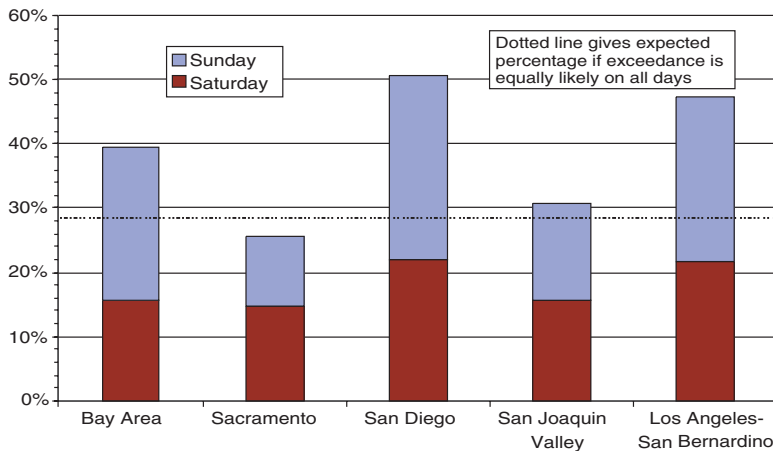
The key to this underreported story can be found in a curious anomaly in the smog statistics: a disproportionate number of exceedances of the ozone standard are occurring on weekends, when emissions of ozone-forming chemicals—especially NO<sub>x</sub>—are down anywhere from 10 to 40 percent. (The reduction in NO<sub>x</sub> emissions comes chiefly from the sharp decline in diesel truck traffic on weekends.) Figure 3 displays the proportion of ozone exceedances in California air basins that occurred on Saturdays and Sundays between the years 1997 and

2001; the dotted line in figure 3 indicates the proportion of exceedances that would be expected if exceedances were distributed equally among all seven days of the week. Figure 3 may actually understate the phenomenon; at some monitoring locations in the Los Angeles area, weekend exceedances account for nearly 80 percent of total exceedances. (See figure 4.) And recall once again that these ozone increases are occurring in spite of large declines in NO<sub>x</sub>. Although the “weekend effect” is most pronounced in California, it is becoming increasingly prevalent in other cities across the nation, including Denver, Chicago, Philadelphia, and New York.

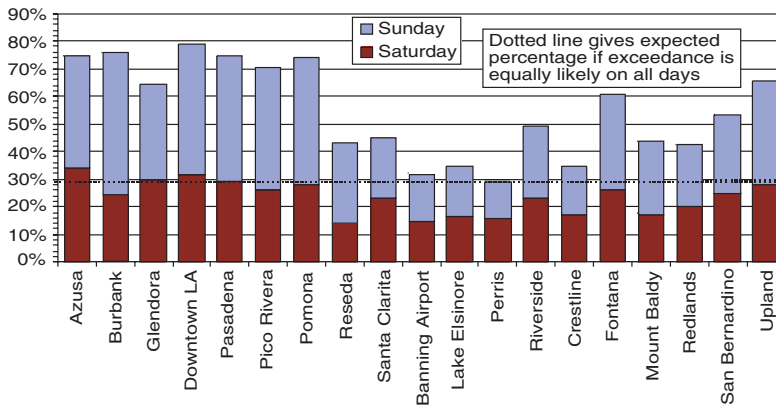
Although the news media and many environmental activists are oblivious to the weekend effect, the phenomenon is well known to air-quality scientists, who have been giving the matter increasing scrutiny over the last several years. The California Air Resources Board (CARB) established a “Weekend Effect Working Group” in 1999, and the U.S. Department of Energy’s National Renewable Energy Laboratory has also been actively engaged in studying the issue.<sup>7</sup> The findings of these efforts are startling.

The chief cause of the weekend effect appears ironically to be lower emissions of NO<sub>x</sub>. The formation of ozone from its main precursors (NO<sub>x</sub> and VOCs) does not proceed in a linear manner. Ozone formation depends on the ratio of VOC to NO<sub>x</sub>, and different ratios of VOC/NO<sub>x</sub> lead to very different outcomes. When the VOC/NO<sub>x</sub> ratio is high—greater than about ten to one—ozone formation is limited by the availability of NO<sub>x</sub>, and VOC reductions have no effect on ozone levels. But when the VOC/NO<sub>x</sub> ratio falls below ten to one, VOC reductions begin to reduce ozone. The rub is that under VOC sensitive conditions, reducing NO<sub>x</sub> increases ozone. Urban areas tend to have the lowest VOC/NO<sub>x</sub> ratios and are therefore the most VOC sensitive. During the last few decades the VOC/NO<sub>x</sub> ratio has been declining in most areas, increasing the weekend effect.

**Figure 3: Percentage of Eight-Hour Ozone Exceedances Falling on a Weekend, 1997–2001**



**Figure 4: Percentage of Eight-Hour Ozone Exceedances Falling on a Weekend, 1997-2001, Los Angeles Air Basin**



To state this confusing matter in inverse terms, higher emissions of NO<sub>x</sub> on weekdays have the paradoxical effect of inhibiting ozone formation. This runs exactly counter to what a common-sense layman would believe to be the case: If there is less pollution coming out of tailpipes and smokestacks, there should be less pollution in the air we breathe. While this is true for most air pollution, it is not always true for ozone.

There are many complicating factors and caveats about the weekend effect, and scientists disagree, as usual, about some of the fine points. But if the foregoing analysis is correct in its essentials, then it raises a startling problem for air pollution policy. Current regulatory policy aims at large reductions in NO<sub>x</sub> emissions over the next few years. What will happen to weekday ozone levels in a few years when *weekday* NO<sub>x</sub> emissions fall to today's level of weekend NO<sub>x</sub> emissions? According to several air quality models, weekday ozone levels would increase

roughly to where weekend ozone levels are today.<sup>8</sup> In other words, regulatory policy is likely to backfire and make ozone worse, at least over the next several years.

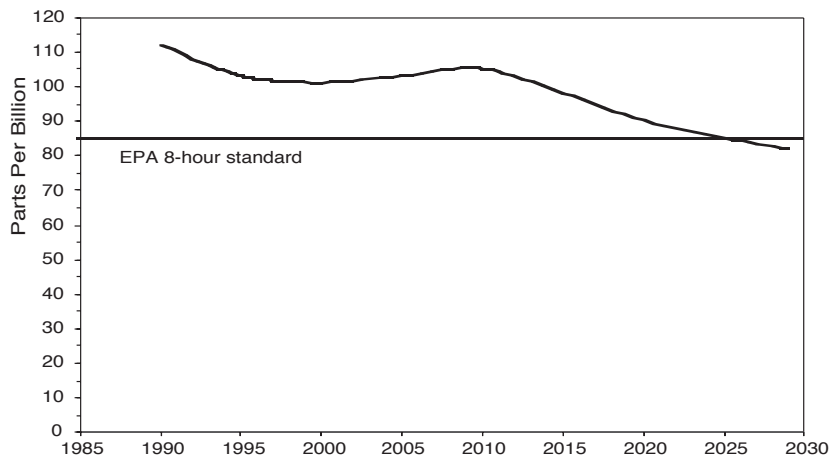
Modeling studies suggest that NO<sub>x</sub> reductions of up to about 50 percent would increase ozone levels in many major metropolitan areas, including New York, Chicago, Philadelphia, southern California, and the San Francisco Bay area. Beyond about 50 percent, the VOC/NO<sub>x</sub> ratio would become high enough that further NO<sub>x</sub> reductions would reduce ozone.<sup>9</sup> In contrast, VOC reductions would reduce ozone at least to some extent almost everywhere and would prove highly effective in some urban areas. However, to attain EPA's stringent eight-hour ozone standard, VOC reductions alone might be insufficient, and NO<sub>x</sub> reductions on the order of 70 to 90 percent would ultimately be necessary in most metropolitan areas. Such large NO<sub>x</sub> reductions are unattainable during the next five to ten years—the amount of time allotted for non-attainment areas to meet an eight-hour standard. This calls into question whether attaining the eight-hour standard is even feasible.

### Backlash to the Backfire

Regulators have been stoutly resisting the implications of the findings about the weekend effect. Admitting that NO<sub>x</sub> reductions have become detrimental to ozone control would be a major embarrassment for both EPA and CARB. Both agencies have promulgated stringent regulations that will eliminate most NO<sub>x</sub> emissions from automobiles and diesel trucks during the next twenty to thirty years, as the fleet turns over to vehicles built to the tougher standards. EPA is also requiring a 60-percent reduction in NO<sub>x</sub> from coal-fired power plants starting this year.

CARB especially has been vigorously resisting the conclusions of independent researchers and offering other hypotheses to explain the weekend effect, including a change in the timing of emissions on weekends or carry-over of pollution from increased driving on Friday and

Figure 5: Possible Trajectory of Ambient Urban Ozone Levels under Current Regulatory Policy



Saturday evenings.<sup>10</sup> Most of these explanations are not persuasive, or they merely obfuscate the debate. In fact, CARB's views have failed to pass the rigors of scientific peer review. The July 2003 issue of the *Journal of the Air & Waste Management Association* (JAWMA) devoted a special section to studies of the weekend effect, several of which are cited here. The journal's reviewers rejected CARB's submission.

EPA has similarly resisted the implications of the weekend effect. The technical documentation for EPA's proposed off-road diesel rule, released last May, approvingly cites the CARB paper that was later rejected by JAWMA.<sup>11</sup> Therein lies another irony: when EPA in 1999 promulgated a rule requiring a 90-percent reduction in  $\text{NO}_x$  emissions from automobiles, the agency's own analysis concluded that the rule would increase ozone in many areas of the country.<sup>12</sup>

### Sensible Policy Alternatives

Because of the quirky relationship between  $\text{NO}_x$ , VOCs, and ozone formation, current regulatory policy is leading to the paradoxical world where emissions will continue to fall rapidly, but ambient levels of ozone may increase along a possible path illustrated in figure 5. In the long term, reductions in VOCs and  $\text{NO}_x$  will lead to lower ozone levels; in the short term, however, ozone levels will get worse in many areas.

A more sensible strategy for both the short- and long-term would be for EPA to seek more rapid reductions in VOCs, and, where possible, delay blanket national  $\text{NO}_x$  reductions for several years. What makes this strategy appealing is that VOC reductions

will reduce ozone in most places, especially places where most people live. Furthermore, atmospheric modeling suggests that the detrimental effects of  $\text{NO}_x$  reductions can be somewhat mitigated by front-loading VOC reductions to keep ahead of declines in  $\text{NO}_x$ .

After substantial near-term VOC reductions, later  $\text{NO}_x$  reductions would achieve eight-hour ozone attainment in the long term, but with less harm in the interim. In addition, this change would give each non-attainment area flexibility to tailor its ozone reduction strategy based on the specifics of local emissions and air chemistry.

More rapid near-term VOC reductions are readily available. Automobiles contribute 50 to 75 percent of all VOC emissions, and the worst five percent of cars accounts for half the automobile contribution. These cars can be identified on the road with remote sensing and their owners required to repair or voluntarily scrap their cars for a cash incentive. There is no other means to more substantial, more rapid, or less expensive improvements in air quality.

### Notes

1. Gary Polakovic, "Smog Woes Back on Horizon; After decades of improvement, ozone levels are up in the L.A. Basin, fed by growing traffic and a lack of new pollution controls," *Los Angeles Times*, July 15, 2003, p. 1.

2. Traci Watson, "Smoggy Skies Persist Despite Decade of Work," *USA Today*, October 16, 2003, p. 1.

3. The data in the chart come from Denver's vehicle inspection program and were collected in 2002.

4. For more information on declining auto emissions, see Joel Schwartz, *No Way Back: Why Air Pollution Will Continue to Decline*, (Washington, DC: AEI Press, 2003), [www.aei.org/publications/filer.economic,bookID.428/book\\_detail.asp](http://www.aei.org/publications/filer.economic,bookID.428/book_detail.asp).

5. The data were collected each year in the Caldecott Tunnel in California from 1994–2001 and are reported in A. J. Kean and R. F. Harley, "Trends in Exhaust Emissions from In-Use California Light-Duty Vehicles, 1994–2001" (Warrendale, Pennsylvania: Society of Automotive Engineers, 2002).

6. For background on the New Source Review controversy, see Steven F. Hayward, "Making Sense of New Source Review," *AEI Environmental Policy Outlook*, July 2003, [www.aei.org/publications/pubID.18961/pub\\_detail.asp](http://www.aei.org/publications/pubID.18961/pub_detail.asp), and

Joel Schwartz, "New Source of Confusion," Tech Central Station, August 27, 2003, <http://www.techcentralstation.com/082703A.html>.

7. For a non-technical but detailed account, see especially D. R. Lawson, "The Weekend Effect—the Weekly Ambient Emissions Control Experiment," *Environmental Manager*, (July 2003), pp. 17–25.

8. NREL scientist Doug Lawson succinctly states the problem thus: "The projected 2010 weekday emissions estimates are not greatly different from current weekend ROG [VOC] and NO<sub>x</sub> emission inventories. . . . Using CARB's emissions projections, calculations suggest that weekday ambient O<sub>3</sub> levels in the SoCAB [South Coast Air Basin (i.e., Southern California)] in 2010 might be similar to weekend O<sub>3</sub> concentrations." *Ibid*, pp. 23, 25.

9. E. M. Fujita et al. "Evolution of the Magnitude and Spatial Extent of the Weekend Ozone Effect in California's South

Coast Air Basin 1981–2000," *Journal of the Air & Waste Management Association*, 53, (2003): pp. 864–875; S. Reynolds et al. "Understanding the Effectiveness of Precursor Reductions in Lowering 8-Hr. Ozone Concentrations," *Journal of the Air & Waste Management Association*, 53, (2003): pp. 195–205.

10. See B. E. Croes et al. "The O<sub>3</sub> 'Weekend Effect' and NO<sub>x</sub> Control Strategies: Scientific and Public Health Findings and Their Regulatory Implications," *Environmental Manager*, (July 2003): pp. 27–35.

11. EPA, "Draft Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines. Chapter 2. Air Quality, Health, and Welfare Effects," (Washington, DC: 2003), [www.epa.gov/otaq/diesel.html](http://www.epa.gov/otaq/diesel.html).

12. Abt Associates, "Tier II Proposed Rule: Air Quality Estimation, Selected Health and Welfare Benefits Methods, and Benefit Analysis Results," (Research Triangle Park, NC: EPA, 1999).