

Southwest

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I want to thank the Center for inviting someone to speak on conditions in the southwest. As Don Campbell has shown, there are quite considerable differences in the chemistry of acidic deposition in the west versus conditions in the east and the midwest.

I would also like to begin by thanking my colleagues at the Air Resources Board for sticking with the acid rain program when it wasn't apparent that we would be setting a standard for either acidic pollution or nitrogen or sulfur deposition.

In my opinion, California's acidic deposition is dominated by nitrogenous inputs stemming from our heavy use of motor vehicles. In most of our urban and rural settings, most of the nitrogen is largely deposited as part of gases during what is called the dry half of our year.

This is a map of California (Figure 1). It is the third largest state with a land area of about 164,000 square miles .Because of our geographic and elevational ranges, the total range in deposition varies quite considerably across the state . There are roughly about 1,300 miles of coastline and east-west differences range from about 150 to 250 miles along longitudinal lines.

California's climatology is classified as Mediterranean. What this means is that we have very wet

winters and dry summers. In most parts of the state, about 80 percent of our annual precipitation falls between the period from October to March.

In terms of ecological receptors, there are 10 climates zones, ranging from the deserts in the southeastern part of the state where considerable invasion of grass species is occurring in the deserts. The researchers there are attributing that for now, anyway, to increases in nitrogen inputs due to primarily motor vehicle use.

Our other ecosystem types range from hardwood, mixed conifer, sub-alpine, alpine transition zones in the Sierra Nevada which extends over about two thirds of the state.

In terms of air quality, California's 34 or 35 million residents drive about 800 million miles per day in the state's 15 air basins. This clearly is at the heart of our nitrogen-dominated acidic deposition concerns.

Here is a summary of our statewide emissions inventory for the calendar year 2000 (Table 1). In rough terms, there is about an 11-fold higher amount of NO_x emitted than sulfur dioxide. On a mass basis, the same relationship holds for emissions of gaseous nitrogen and gaseous sulfur.

By source category, the emissions of NO_x are about 80 percent from motor vehicles and about 20 percent from stationary sources and area sources. For sulfur dioxide, about 55 percent comes from mobile sources and about 45 percent from area and stationary sources.

Through our acid deposition monitoring program – and at this point we only have about five wet deposition stations still collecting data –



Figure 1. Map of California.

Table 1.

California Emissions: CY 2000		
Pollutant	TPD	TPY
ROG	3,300	----
NO _x	3,600	600,000 (of N)
SO ₂	300	55,000 (of S)
PM ₁₀	2,400	----

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here is some of the data showing the basis for our concerns with respect to acidic nitrogen (Table 2).

The data in this table are from 10 sites, three urban, four what I have called mixed – and I will explain that in a minute – and three remote forest sites.

At the urban sites, the third line down shows the ratio of total nitrogen to total sulfur deposition. The number for urban systems, 9.1, approximates, roughly speaking, the statewide emission ratio for NO_x and sulfur dioxide of about 11.

Coming next to the mix sites, which are a collection of moderate to small urban areas like Sacramento and Fremont in the San Francisco Bay area, the total nitrogen to sulfur deposition ratio drops to about 5.3, and then it falls another 50 percent to about 2.5 at our remote forest sites.

I want you to take note that, at these three classes of receptors, total nitrogen drops from about 23 to 3 kilograms of nitrogen per hectare per year, while sulfur drops from about 2.5 to 1.5.

Another point I would like to make is on the fourth line, the importance of dry nitrogen deposition. It accounts for anywhere from 80 to 90 percent of total nitrogen deposition in our urban and mixed sites, only about 40 percent in our forest sites.

With state funding, we were able to conduct an effects research program in five areas. Our human health research focused on the effects of acidic fog and nitric acid vapor alone and in combination with other pollutants in both human and animal systems.

Our aquatics program focused on wet deposition effects to high elevation systems in the Sierra Nevada. That includes an intensive study site at Emerald Lake in Sequoia National Park.

Forest program studies were conducted to assess the combined effects of ozone and atmospheric nitrogen on a mixed conifer forest in Southern California and, for agricultural crops, we did acidic fog studies to characterize structural and physiological impacts.

In our manmade materials program, we looked at the effects of ambient Southern California air on deterioration rates in a range of building materials.

For acidic fog, acute exposure studies were conducted. The work of Shepherd and others in the University of California system indicated that a lot of the observed changes in lung function were largely associated with the application of the water droplets alone. Acute exposure studies using nitric acid vapor indicated slight changes in airway reactivity and inflammation when using above ambient exposures to nitric acid vapor.

In terms of chronic effects, an important finding was recently reported as a result of the airborne children's health study. This is an epidemiological study being conducted in 12 communities in Southern California. Researchers from the University of Southern California have found an association between ambient concentrations of NO_x, PM₁₀ and nitric acid vapor and reductions in what is known as lung function growth, which is a physiological response in children living in the most polluted communities. This suggests that there is a potential for increased risks of chronic respiratory illness in adulthood, which stems from a reduction in the maximum lung function that can occur as a young adult.

In terms of air pollution, as was mentioned earlier, studies conducted since the 1950s have shown that ambient ozone has an adverse effect on pines in Southern California. In our forest program, research looked at the combined effects of ozone and nitrogen deposition, as ozone is an over-arching pollutant stress, and reports of nitrogen saturation were quite prominent in the literature.

Researchers from the U.S. Forest Service in Riverside conducted a three-year study at Barton Flats, which is in the San Bernardino National Forest. At this particular forest site, the daytime ozone level is about 60 parts per billion and the nitrogen deposition rate is about five to nine kilograms per hectare per year. This is what they

Table 2.

CADMP Multi-year Data			
	Urban	Mixed	Remote
Total N	23.0	9.2	2.9
Total S	2.5	1.7	1.5
N:S	9.1	5.3	2.5
% Dry N	92	84	40
% Dry S	63	54	20

considered to be a mid-range forest site along this west to east ozone gradient that occurs in the San Bernardino Mountains.

The high side at the western end is a place called Camp Pifica. At Camp Pifica, the daytime ozone levels are about 90 ppb and nitrogen deposition is about 30 to 40 kilograms per hectare per year.

Using the nutrient cycling model developed for the integrated forest study, this group found that the potential for chronic soil acidification and aluminum toxicity was fairly low, but that rates of soil nitrogen emissions were comparable to those that you can measure in agricultural fields. As a follow on to these studies, these researchers also measured nitrate levels in streams from the watersheds. The highest nitrate levels were observed at rates exceeding the highest atmospheric nitrogen loads.

Our studies on aquatic systems looked at the effects of high elevation links in the Sierra Nevada above 2400 meters elevation.

Researchers from the University of California, Santa Barbara, documented that snow is the main source of water and analytes to these systems, but summer rains could also be a significant source for both acidity and nitrogen.

Although many lakes were surveyed, there was no indication, as Don Campbell indicated, of chronic acidification. Episodic acidification does occur pretty much every year during snow melt in the spring. In terms of biological effects, episodic acidification was linked to reductions in the populations of some invertebrates as well as some spring spawning fish species.

In keeping with the theme of the conference, is California's acidic deposition problems solved? In some ways, yes, and in some ways no.

I think yes in terms of, there is a commitment to pursue further emission reductions of both criteria in toxic air pollutants, and no in terms of not being able to fully appreciate what the extent of chronic health and ecological effects may be.

Our air quality data indicate that acid precursor emissions are headed down. By 2010, ambient air quality will be improving in urban areas of the state.

Without improving revisions to our state implementation plan, more measures will be

adopted to reduce NO_x emissions to control ozone, PM₁₀ and acid deposition as a secondary or contributing stress to both human and forest health.

By focusing our control programs on ozone and PM₁₀, it is anticipated that there will be concurrent reductions in any potential effects that could occur from acidic pollutants.

The phrase, uncontrollable externalities, comes from my economic friends. Given our current energy crisis in California, some concessions may have to be made in terms of air quality to meet the greater good of California.

I guess over the next 50 years or so, only time will tell if we are embarking on the right kind of program. Thank you.

QUESTIONS

DR. COWLING: Brent, you have a huge concentration of animals in the lower part of California, the central valley. I wonder if the state has a good ammonia emissions inventory.

MR. TAKEMOTO: As of about three years ago, there has been a very concerted effort to at least identify where all the feedlots and dairy facilities are located. As you mentioned, in the San Joaquin Valley, there is an increase in their production. It has been a three-year work in progress, but that was certainly one of the issues, and that was driven by particulate matter concerns of ammonium nitrate.

MR. COWLING: We also heard a very interesting report on ammonia emissions from automobiles. I wonder if you could comment on your sense of the inventory development attributing ammonia emissions to animal agriculture and automobiles, on the other hand?

MR. TAKEMOTO: I am not sure exactly who did that work. It might have been either Cal Tech or Desert Research, I am not sure. There are significant, or at least measurable, ammonia emissions from cars.

We have one of the most complex models for looking at vehicle emissions, and that is also being worked into the process as well. What the nitrogen outputs from cars, ammonia, derived from ammonia will be, and how that could possibly affect our strategies for PM₁₀ will be studied.

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