Who killed the fog? UC Berkeley nabs a suspect

By Lisa M. Krieger, (San Jose) Mercury News
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Scientists have cracked the cold case of the Central Valley's missing fog.

Tule fog – a thick white veil of condensation that shrouds the valley on winter mornings – has been slowly vanishing over the past three decades. Foggy days steadily increased between 1930 and 1970, but have since declined.

The suspect: Clean air, according to new research by UC Berkeley researchers. As pollution declines, so does the fog.

That's because tule fog's droplets form around particles that are created, in part, by nitrous oxide emitted out of the tailpipes of vehicles.

Since passage of the Clean Air Act in the late 1960s, nitrous oxide levels in the Central Valley have steadily declined, reducing the number of dirty particles available for fog formation. To be sure, there is still some nitrous oxide, or NOx, in the air, the product of agricultural fertilization. Just not as much.

"When we looked at the longterm trends, we found a strong correlation between the trend in fog frequency and the trend in air pollutant emissions," said UC Berkeley graduate student Ellyn Gray in a prepared statement. The research appears online Wednesday in The Journal of Geophysical Research: Atmospheres.

The link between air pollution and fog also explains why southern parts of the valley, with worse air, have a much higher occurrence of fog than northern parts of the valley. Conventional wisdom would predict fog would be rarer in the south, because it's warmer.

The fog's disappearance has been a most peculiar mystery, spurring intrigue. It just faded, leaving no trace.

For drivers, it's good riddance. The dense fog is notorious for causing deadly accidents.

But the fog is missed by farmers, who welcome its contribution to the long winter dormancy needed by fruit and nut crops. Fog shields the trees from sunlight, keeping their buds cooler.

In search of clues, the Berkeley researchers studied weather and air pollution data from the Central Valley as far back as 1930.

Their conclusion: While yearly fluctuations in fog frequency were linked to changes in annual weather patterns, the long-term trends matched those of pollutants in the air.

For every 10 parts per billion decrease in NOx, there was a decline of five fog days per year, the team found.

The results help explain the puzzling up-and-down pattern of "fog days" in the region. Fog days climbed 85 percent between 1930 to 1970, when the region was increasingly farmed and industrialized. They fell 76 percent between 1980 to 2016, after the enactment of air pollution regulations.

The changes in fog frequency didn't correlate with changing temperatures due to climate change, according to the team's analysis. That deepened the mystery of its disappearance.

"In order to get fog to form, not only do you need the temperature to go down, but there has to be some sort of 'seed' for water to condense around," according to Gray.

That's a different pattern than noted in the Bay Area's famed summer fog. The thinning fog seems to be more directly influenced by weather – specifically, warm and stagnant spots in the Pacific Ocean.

"When I was growing up in California in the 1970s and early 1980s, tule fog was a major story that we would hear about on the nightly news," said Allen Goldstein, a professor in the Department of Environmental Science, Policy, and Management, and in the Department of Civil and Environmental Engineering at UC Berkeley, in a prepared statement.

“These tule fogs were associated with very damaging multi-vehicle accidents on freeways in the Central Valley resulting from the low visibility,” he said. “Today, those kind of fog events and associated major accidents are comparatively rare.”

Study: As the valley's air pollution has declined, so has its infamous tule fog

By Steven Mayer
Bakersfield Californian, Wednesday, April 17, 2019

California's Central Valley residents have speculated about the cause of the region's air pollution almost as often as they've opined about the frequency of the valley's dense tule fog.

Now they can combine both of those conversations into one.

Scientists at UC Berkeley have found a strong correlation between the trend in fog frequency and the trend in air emissions. As air pollution in the valley worsened during the mid-20th century, the number of fog days increased, said Ellyn Gray, a graduate student in environmental science, policy and management at UC Berkeley and first author on the paper, which appears online in The Journal of Geophysical Research: Atmospheres.

Yes, the changing climate played a part, as did urban sprawl, which increased the concrete footprint of cities. But neither of those factors, Gray said, can account for the decline of tule fog in both rural and urban environments.

"Urban expansion is likely shortening fog events by a few hours at city centers," Gray said. “But its impact is really dwarfed relative to the decline in the overall fog season we're seeing.”

"A number of satellite studies, as well as rural meteorological stations ... have confirmed that the tule fog decline occurred at both rural and urban stations," she said. "If the change was driven predominantly through urban expansion, we wouldn't see the same magnitude decrease in rural sites."

In fact, most of the airports that collect weather data are already outside the urban center, Gray noted. That gives study authors even greater confidence that sprawl is not the answer.

Similarly, rising temperatures due to climate change, which has been thoroughly documented in recent decades, cannot explain the reduction in fog frequency, Gray said.

The southern valley is warmer, and yet the fog remains more frequent here than areas to the north. Why?

Pollution concentrations are higher in Bakersfield and Fresno, Gray said. Yet there's more fog in the southern part of the valley, despite the warmer overall temperatures.

Study authors "analyzed seven decades of meteorological data and five decades of air pollution data to determine the most likely drivers changing fog, including temperature, dew point depression, precipitation, wind speed, and NOx concentration," the study said.

They concluded that while the short-term fog variability is dominantly driven by climate fluctuations, the longer-term changes in fog have been driven by changes in air pollution.

Dennis Baldocchi, a professor of biometeorology at UC Berkeley, and a co-author of the study, grew up in the valley and remembers his dad driving the family home in fog so dense the road seemed to disappear below you.

Valley residents who grew up in the 1950s, '60s, and '70s, may have believed, and understandably so, that the valley's extreme wintertime fog conditions were normal, Baldocchi said. And why not?

During those years, multiple days of heavy wintertime fog were just part of life in the valley.

But it hadn't always been that way. Study authors were surprised to find that the frequency of tule fog in the valley increased 85 percent from 1930 to 1970, then declined 76 percent between 1980 and 2016.

This period in the mid-20th century when air pollution was extreme coincided with a period of extreme fog.

That rise in fog frequency mirrored the region's explosion in population, vehicle use, farming and industrialization.

Following the enactment of the Clean Air Act 1970, particle emissions quickly declined, and NOx (oxides of nitrogen) emissions declined steadily, researchers said, reducing NOx, which help form seed particles known as "cloud condensation nuclei" that are necessary for fog formation.

Why should we care?

The benefits are in improved public health, in fewer school fog delays and fog-related pileups and traffic fatalities, Baldocchi said.

But fog can also be beneficial to the agricultural industry. Several crops, including almonds, pistachios and cherries, require a minimum number of "chilling hours" during the trees' wintertime dormancy period to produce at their maximum potential.

Some local growers have reported problems related to lack of chilling hours.

Fog can maintain those hours of cold, while at the same time, guarding against a hard freeze, the kind of cold that can damage fruit and other farm commodities.

But there's more work to do.

"This study has helped us dot the I's and cross the T's," Baldocchi said.

But these studies build on each other, he said. And there are always new questions to explore.