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William Bowman, director of the University of Colorado Mountain Research Station on Niwot Ridge, studies how nitrogen compounds from Front Range tailpipe emissions, feedlots, crop fields and power plants are transforming vegetation, lakes and streams along the Continental Divide.

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# Pollutants raining down on Rockies: Nitrogen buildup putting national park's ecosystem at risk - and it could get worse, research shows

By Jim Erickson

ESTES PARK - Airborne pollutants from Front Range tailpipes, smokestacks, crop fields and feedlots are damaging the prized mountaintop ecosystems of Rocky Mountain National Park.

If unchecked, the creeping accumulation of urban nitrogen compounds could acidify park waters and soils, posing a threat to fish, forests and vast expanses of rolling alpine tundra, National Park Service air-quality officials have concluded after reviewing more than 20 years of research.

As it is, the Park Service has concluded that a crucial threshold called a "critical load" has been crossed and that harmful changes are occurring. When plants and soil are saturated by a pollutant, runoff is next.

"When the fish are floating belly up, it's too late," said Christine Shaver, chief of the federal agency's air resources division. "We want to find some way to see if we can halt or reverse the harm we're seeing now, before it gets to that point," she said.

For two decades, park researchers have watched with alarm as levels of nitrogen compounds from Front Range auto exhaust, coal-fired power plants, gas and oil wells, crop fertilizers and livestock manure inched higher and higher.

Now, for the first time in its history, the Park Service will use the concept of critical loads to argue for reductions in emissions affecting a national park, Shaver said.

Last month, the Park Service began meeting with state health officials to look for solutions to the problem, which is known as nitrogen deposition.

One idea being floated by the Park Service is to add nitrogen deposition to ozone- and haze-reduction programs already in the works at the Colorado Department of Public Health and Environment.

If Colorado officials don't respond, the Park Service could ask the U.S. Environmental Protection Agency to force the state to take action.

"It is our responsibility - under our own statutory mandates - to preserve our resources unimpaired for future generations," Shaver said.

Established by Congress in 1915, Rocky Mountain National Park straddles the Continental Divide and is visited by more than 3 million people each year.

The 415-square-mile park boasts more than 110 peaks higher than 10,000 feet. More than 100 square miles of the park lie above tree line - a landscape of granite, ice and alpine tundra.

Periodic easterly upslope winds have been dumping urban nitrogen compounds onto the park for decades, where they fall in snow and rain, said Jill Baron, an ecosystems ecologist with the U.S. Geological Survey in Fort Collins.

If the problem continues to grow, researchers fear nitrogen pollution will mimic the effects of acid rain, which has killed forests and sterilized waterways in the eastern United States, central Europe and Scandinavia.

**Pollution hits tipping point**

Baron and her colleagues have monitored precipitation and surface water chemistry, weather and stream flow in the park's Loch Vale watershed since 1982. The Loch Vale study is one of the longest-running and most closely monitored studies of subalpine forest in the United States.

All of the changes detected to date are subtle responses to the fertilizing effects of nitrogen compounds.

Ammonium nitrate is a common crop fertilizer. It's also the explosive Timothy McVeigh used in the Oklahoma City bombing.

Ammonium and nitrate are two of the nitrogen compounds raining down on the Rockies. In the Loch Vale watershed, which hugs the east flank of the Continental Divide south of Bear Lake, the fertilizers have:

• altered the growth of 300- to 700-year-old Engelmann spruce trees;
• caused formerly rare types of algae to bloom in previously limpid alpine lakes;
• changed soil chemistry;
• flushed excess nitrogen into the streams.

These changes are imperceptible to the passing hiker, but park officials say they're consequential because the agency has a mandate to preserve wild places in a natural and unimpaired state.

"Natural is not treating those trees like a tree farm, where you dump extra nitrogen on them and they grow better," said Park Service ecologist Tamara Blett.

Nitrogen deposition has been increasing in the park by about 2 percent a year for the last two decades.

The current annual nitrogen deposition level in the park is about 3.92 pounds per acre. That's about 15 times higher than preindustrial levels, according to a fact sheet the Park Service began distributing at the Beaver Meadows visitor center.

The current levels of nitrogen exceed the critical load - the tipping point at which a pollutant begins to damage ecosystems, according to the Park Service.

Once that threshold is passed, plants and soils reach saturation. The excess pours into waterways.

Based on evidence from other parts of the world plagued by acid rain, the next step will be acidification of the park's highest-altitude streams.

Computer models suggest it won't happen for another decade or so, Baron said. But once it does, dead trout are sure to follow, she said.

Acids also can rob nutrients from the soils, weakening trees and making them susceptible to disease and insect attacks.

"It hasn't happened yet. Nevertheless, it's coming," said Baron, who heads the Loch Vale project. "We're at the beginning of a trajectory of change that will only get worse and worse.

"And if we keep increasing emissions, we will see acidification, we will see dead fish," Baron said.

**'Place that inspires millions'**

Park Service officials are still trying to nail down the exact nitrogen deposition level that constitutes a critical load for Rocky Mountain National Park.

In coming months, they will settle on a specific number, then use it to push for emissions reductions, Shaver said.

Vickie Patton, a senior attorney at the Boulder office of Environmental Defense, praised Park Service officials for using the critical-load approach because "it brings to bear the very best science available to inform public policy action."

But she said the Park Service is not moving fast enough or pushing hard enough to address nitrogen problems in the park.

Under the federal Clean Air Act, the Park Service is charged with an "affirmative responsibility" to protect places like Rocky Mountain National Park from the harmful effects of air pollution, Patton said.

"The Park Service can and should do more," Patton said. "We're talking about the crown jewel of Colorado and a place that inspires millions of Americans."

Douglas Benevento, executive director of the state health department, said his agency wants to help solve the park's nitrogen deposition problem.

But it might not be prudent to fold nitrogen deposition into the ozone and haze reduction programs, as Shaver suggested, he said.

It might make more sense to begin by measuring the effect those programs - along with the introduction of cleaner-burning gasoline recently mandated by the EPA - will have on nitrogen emissions along the Front Range, he said.

"We need to pinpoint where we're at now, and then from there determine if more needs to be done," Benevento said.

And though park researchers contend that Front Range nitrogen emissions are the main culprit, Benevento said he's not convinced.

"If we were to cut by half everything along the Front Range, I'm not sure that would solve any problem that exists at Rocky Mountain National Park," he said.

Westerly winds blow pollutants into Colorado from West Coast states and beyond, he said.

"There are a lot of out-of-state sources that we need to factor into this - California would be a good place to start - to try to determine what a solution would look like," he said.

**Vehicle exhaust top offender**

In addition to identifying the pollutants' origin, the Park Service and regulatory agencies need to get specific about the emissions sources that are to blame, said Frank Prager, managing director of environmental energy for Xcel Energy.

Xcel operates three coal-fired power plants in the Denver area and several others around the state.

Between 1995 and 2002, the company reduced nitrogen oxide emissions from its Colorado plants 27 percent by installing so-called low-NOx combustion technology, Prager said. The improvements cost $31.2 million and cut nitrogen oxide emissions by about 14,500 tons per year.

"If additional power plant reductions are necessary and required under the Clean Air Act to address this concern, we will be there, as we always have been," Prager said.

"But we want to make sure that the things we're going to be doing are actually going to result in preserving the park for future generations."

Baron and her colleagues believe the main source of the nitrogen compounds reaching Rocky Mountain National Park is the South Platte River Basin, home to about 2.9 million Coloradans - about two-thirds of the state's population.

Vehicle emissions account for 45 percent of the basin's nitrogen emissions, according to a new study by Baron and other researchers at Colorado State University's Natural Resources Ecology Laboratory.

Coal-fired power plants and other "point sources" of nitrogen emissions are responsible for about 34 percent of the nitrogen emissions.

Nitrogen compounds from synthetic crop fertilizers and ammonia from manure in feedlots account for 11 and 10 percent of the emissions, respectively. Winds scour the gases and particles off the crop fields and feedlots and blow them into the mountains.

**Emissions still on upswing**

By analyzing layers of sediment in high-altitude Rocky Mountain National Park lakes, researchers have concluded that nitrogen levels began to soar around 1950. The types of algae in the sediments remained essentially unchanged for the 14,000 years preceding 1950, then abruptly shifted in an apparent response to added nitrogen.

The widespread application of synthetic nitrogen fertilizers on irrigated cropland began in the late 1950s in the South Platte Basin. While the acreage devoted to crops has decreased by about 2 percent in eastern Colorado since 1950, irrigated acres increased by about 73 percent during that span, Baron and her colleagues found.

The rise in acreage devoted to irrigated corn and alfalfa hay accompanied an increasing demand for livestock feed in eastern Colorado over the last half century. During that time, the South Platte Basin became a national center for feedlot operations.

By 1995, the basin was home to 1.3 million cattle, 278,000 hogs, 327,000 sheep and 2.9 million chickens. More than half of those cattle are in Weld County.

Until the 1960s, the South Platte River Basin's economy was dominated by agriculture, and the region had about 800,000 residents. The population jumped from 1.9 million to 2.9 million between 1980 and 2000, with most of the growth along the urban corridor stretching from Denver and its suburbs north to Fort Collins.

As the basin's population grew, so did emissions of nitrogen oxides from vehicles, factories and coal-fired power plants. Urban and industrial processes replaced agriculture as the leading sources of nitrogen emissions, according to Baron and her colleagues.

Nitrogen emissions are still increasing in most of the 16 counties in the basin, they found.