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Kicking up dust

How did desert dust land in high-mountain lakes?

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Jason Neff reads the muck extracted from alpine lakes the way you might read a history book. What he found in his study of two lakes high in the San Juan Mountains is a steady, mild accumulation of dust for about 5,000 years.

But then, about 150 years ago, there was a huge increase in dust, about 500 percent more in any given year.

What changed 150 years ago? Neff, a biogeochemist at the University of Colorado at Boulder, thinks the change was due to introduction of cattle and other livestock onto the deserts of the Southwest in large numbers.

Jason Neff with a sediment-coring device in Porphyry Lake in the San Juan Mountains. Neff's research has shown that dust accumulated in high-mountain lakes in southwest Colorado has migrated from the deserts of the Four Corners region. (University of Colorado)

“It’s borderline impossible to explain this without humans,” he says.

Neff’s report is the latest to document how activities of man in one area have had consequences in distant places as a result of wind deposition. In Antarctica, study of ice cores has revealed a surge in dust about the time that large-scale grazing began in the Patagonia area of South America. In Greenland, another ice core showed surging pollution of black carbon peaking with the widespread burning of coal in North America and, more recently, from China.

The study of airborne particulates “is becoming one of the hottest areas of climate change,“ says Joe McConnell, a scientist at the Desert Research Institute in Reno, Nev. Scientists, he says, are still assessing how much climate change can be attributed to man-made causes and how much because of natural climate change.

Neff’s work also complements that of Tom Painter, a scientist now based in

Salt Lake City who released a report last summer showing dust from the Southwest deserts is causing annual snowmelt in the San Juans to begin eight to 32 days earlier.

Fieldwork for both experiments was conducted by the Silverton-based Center for Avalanche and Snow Studies. Chris Landry, a former Roaring Fork Valley resident, is the executive director.

Icing on the cake

Neff and Painter both began their projects in 2003, but for different reasons. Neff was in the San Juans to study nutrient cycling in ecosystems, to determine how the composition of the underlying rocks affects what kinds of trees grow.

But rocks are not the sole source of nutrients. Dust blown in from other areas always has been a part of the alpine ecology.

To better understand this, Neff took samples of the mud from the lakes. The lakes, located slightly above timberline at about 12,000 feet in elevation, were chosen because they showed no evidence of disturbance, as from mining or other activities.

Core samples taken from the muddy bottoms of mountain lakes show that livestock grazing in the mid-19th century accelerated dust migration from the deserts to the high mountains. (Center for Snow and Avalanche Studies)

He found small increments of dust over some 5,000 years, but the dust accumulation suddenly accelerated in the mid-19th century. The time sequence is determined by radiocarbon dating of twigs and other debris found in the mud.

But how can he tell where the dust came from?

Neff says there are two keys. Texture is one. If the particles are large, they're not from Asia. Dust from Asia does blow into North America, but previous research has shown that larger particles, such as are found in the San Juan lakes, are not routinely carried that far.

The icing on the cake, he says, are the isotopic signatures of the materials, which show they were not from surrounding bedrock. In fact, they look very much like the dust-on-snow documented in Painter's research. If the precise provenance of the San Juan dust samples is difficult to determine, the chemical signatures overlap with the basement rocks of Arizona, New Mexico and northern Mexico.

Further evidence of the regional source is satellite detection of dust plumes rising from the Southwestern deserts at about the same time as dust is deposited on San Juan snow. Scientists also use something called atmospheric back-trajectory modeling. This technique allows them to trace wind speed and velocity recorded when the dust fell on snow to determine the probable source.

The case for cattle

The "clear and abrupt transition" in the lake core sediments can only be explained by intensified land use in the West, says Neff.

Although cattle and sheep grazing had been introduced to the Southwest by 1600, he says, it took the arrival of railroads after the Civil War to make it a large-scale commercial activity. Within a few decades, the number of grazing livestock had increased from a relative few to 40 million. By the early 1930s, two-thirds of the land area in northeastern Arizona had been significantly disturbed by livestock use.

"Overall, nearly 70 percent of the natural ecosystems of the western United States have been affected by livestock grazing, resulting in loss of soil stability and increases in wind erosion of soil," said Neff in an article published in Nature Geoscience.

However, deposition of lake sediments slowed in the 20th century. Again, Neff thinks he has an explanation. Because of the extensive degradation of the rangelands, Congress in 1934 passed the Taylor Grazing Act, named after Edward Taylor, the Glenwood Springs-based congressman (and one-time Aspen and Leadville lawyer) who represented Colorado's Western Slope. The law established controls on grazing of public lands and established the Grazing Service to administer those laws. The agency later became the Bureau of Land Management.

Neff also found evidence of increased phosphorous, nitrogen and carbon in the lake sediments. Again, he finds it difficult to explain these spiked levels without the influx of humans, but is less conclusive about the links. He said he hopes to expand his research, both into the Sangre de Cristo Range of New Mexico and into Colorado's northern mountains.

McConnell wasn't surprised by Neff's conclusions. "It is consistent with what we have found in the polar regions," says McConnell, who directs the Ultra-Trace Chemistry Laboratory at the Desert Research Institute.

Taking ice core samples on the North Antarctica Peninsula, McConnell found a doubling of dust that was concurrent with the introduction of sheep in Patagonia.

McConnell, in studying Greenland ice, also finds evidence of industrialization, this time with a sevenfold increase in concentrations of black carbon. The increase began about 1850, then accelerated sharply during the late 19th century before declining slowly.

But the ice core study in Greenland also shows success. In the early 1970s, the Clean Air Act was implemented in the United States, with similar efforts under way in other countries. The success of that regulation, he says in a report published last year in the prestigious journal Science, is reflected in the ice, "with a sharp drop almost to pre-industrial levels by 2002."

A disturbing agent

This latest report also is consistent with findings by Jayne Belnap, a research ecologist with the U.S. Geological Survey who works out of Moab, Utah.

Dust will blow naturally from some deserts, she says, but not from the deserts of the Southwest.

“The dust just doesn’t blow. You have to have a disturbing agent,” says Belnap, who has conducted experiments to prove this. To explain the amount of dust recorded in the San Juans, she sees only one feasible explanation: cattle.

What this new report also points to is the transfer of nutrients from deserts to alpine ecosystems. Adding nutrients to the high mountains favors some plants over others, she says. At the same time, the deserts lose fertility.

But dust is also interesting because of its role in the changing climate, even if the precise role of dust remains unclear.

Dust in the atmosphere is “going to be both heat-absorbing and it’s going to prevent heat from entering the atmosphere,” explains Belnap. “So it’s very complicated, and no one really understands the total impact.”

Also still uncertain is the role of dust on snow. As documented by Painter’s study, dust decreases the amount of time that snow lingers on the ground, owing to how darker material more readily absorbs solar radiation. This, in turn, causes the ground to heat up, possibly accelerating global warming.

“People are really scratching their heads, trying to figure out how to get this into the global climate models,” says Belnap. “But nobody is arguing that it doesn’t belong in there.”

No pointed fingers

Neff says that in studying ecosystems, often the processes are very subtle. “But when you look at these sediment cores, there’s nothing subtle about what happened 100 to 150 years ago. There is this dramatic, remarkable alteration that is actually telling the story of settlement.”

The broader lesson, he says, is that we always affect our environment, in ways both expected and unexpected.

This matters in part, he says, because if federal land managers are required to manage for “pristine” conditions, then they must first understand what is pristine.

Still, Neff is leery of being seen as pointing fingers. “No one scientific finding should ever dictate a particular policy,” he says.

But, he adds, it should spur further thought to the link between land use and hydrology and climatic conditions.

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