Dust takes a toll

Soil in the West's air disrupts health, snow cover, even rainfall

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Imtiaz Rangwala studies climate change on the Tibetan Plateau and, more recently, in the American West. In mid-May, the climatologist flew into Durango, Colo., through skies darkened by dust. The next day, the dust had settled on the San Juan Mountains, where Rangwala was checking on the snow. "As far as my eye could see -- up to 11- or 12,000 feet -- there was dust all around," he says.

Much as they did last year, billowing gusts of dust from the Arizona desert have blanketed southwestern Colorado. The dusty air that clouded visibility during Rangwala's flight forced the closure of a 22-mile stretch of I-40 from Winona to Winslow. In late December, similarly thick dust clouds along I-10 in the Phoenix area caused a 20-car pileup that killed three people.

Dust is nothing new in the Southwest. Sediment records show that settlers and their livestock started kicking up dust in the region 150 years ago. Despite a reduction in grazing, continued disturbance by grazing animals, off-road vehicles and plows -- exacerbated by drought -- is sending the soil flying again. The recent onslaught of dust in Southwestern skies affects human health and safety -- and also, as scientists are discovering, the region's climate.

In the San Juans, University of Colorado researcher Jason Neff and his colleagues are piecing together a 5,000-year-long history of Southwestern dust. By studying sediment cores from high-elevation lakes, they found that little dust moved around the region until cattle arrived in the West in the second half of the 19th century. By last century's end, the amount of dust landing in the San Juan Mountain sediments had increased fivefold.

Seeking to find out why so little dust moved around before cattle arrived, Neff measured soil dynamics at an ungrazed site, one that retains the biological crusts that once coated desert soils throughout the West. The mystery was solved. "You can blow 80-mile-an-hour winds across the crust environment," Neff says, "and no soil will move." These biological crusts -- communities of bacteria, algae, fungi and lichens that take decades to form -- quickly crumble and disappear under pressure from hooves, vehicles and farm machinery.

Many changes since the mid-1800s have broken the protective crusts. Utah's deer population -- currently managed for trophy hunting -- has expanded from about 15,000 to 430,000, says U.S. Geological Survey scientist Jayne Belnap, who tracks dust and its sources. The explosion in human population, with Arizona, Nevada and Utah among the fastest-growing states, means that a lot more vehicles are driving and four-wheeling across the desert. Farming that was once

confined to small plots near local streams now covers massive fields. And soil on dry plowed lands is easily picked up by strong winds, as farmers found during the 1930s Dust Bowl drought.

Biological crusts quickly vanish under such disturbance. Yet these crusts, which once filled the spaces between desert plants, excel at holding down soil. Just how effective they are was shown in a nine-year study led by Belnap and USGS researcher Richard Reynolds that compared dust emissions from undisturbed versus grazed sites. "The most striking finding," Reynolds says, "was the different responses among the sites during the drought of 2002."

In years of average rainfall, the disturbed sites produced about three times more dust than the non-grazed sites. In drought years, the most disturbed site produced some 5,600 times more dust than a site that was never grazed. "It got to the point where we couldn't keep up with the dust collectors," even changing them every week, Belnap says. "Basically, what we've been finding is that desert surfaces are pretty stable unless they've been disturbed. It's D-cubed: dust, drought, disturbance."

In 2009, drought and land disturbance abetted by high winds combined to produce an unusually dusty year, according to five years of snow studies by scientists in the San Juans.

"In 2005 through 2008, we were measuring concentrations of dust in parts per million," says Thomas Painter of California's Jet Propulsion Laboratory, who led the San Juan studies. "In 2009, we had to retool our measurements to be measuring in parts per thousand.

Painter says last year's levels were five to 20 times higher than other years measured -- unusually high even in the longer term, based on his conversations with locals. He and his colleagues are tracing the spike back to an overall lack of spring "greenup" in northeastern Arizona during 2009, which they attribute to poorly timed rains. With only sparse grasses holding down soil and most of the biological crusts long gone, strong winds blowing from Nevada carried tons of dirt off in clouds bound for Utah and Colorado.

The situation in northeastern Arizona has become dire, with sand dunes mobilizing across the Navajo Reservation and dried-up mud flats south of I-40 spewing dust, says USGS scientist Margaret Hiza Redsteer, based in Flagstaff. "Last year was a particularly dry year after many, many dry years during this current drought," she says. Unusually strong winds added to the problem, she notes. "We're also having warmer temperatures than we've had in the past, and that increases aridity." Many climate models indicate that the increased aridity of recent years will become the future norm as the air continues to warm and raise evaporation rates.

Urban dust -- concentrated around cities and drifting into mountains along with desert dust -- consists not only of soil particles but also pollution from fireplaces and car exhaust, including the small particles that are particularly dangerous to human health. Tens of thousands of Americans die prematurely every year from breathing in small particles, Reynolds notes, because the dust weakens the lungs, which in turn stresses the heart.

The dust also makes snow more vulnerable to an early meltdown. Soot -- produced by burning wood, coal and diesel fuel -- and soil particles are the worst offenders, heating up the air while they remain afloat. When they come to rest on snow, their dark colors cause the snow to heat much faster.

The early melting of snow, in turn, has been linked to an increase in the number of big Western wildfires since the mid-1980s. It means problems with the system of reservoirs dotting the West and less available water throughout the Colorado River Basin.

Dust has other, more subtle, effects. Scientists are finding that it can change rainfall patterns much the way global warming itself does. In a double whammy for Southwesterners, particulate pollution can increase the likelihood of both more extreme drought and more severe storms.

"It turns out that if you put too many particles in a cloud, it can actually prevent rainfall," says Meinrat Andreae, an atmospheric scientist and air pollution expert with the Max Planck Institute in Germany. The small particles from car exhaust and coal-powered electrical plants can shape water vapor into droplets too tiny to overpower the wind currents keeping them afloat. Sometimes the drops evaporate without ever reaching the ground.

On the other hand, dust and other mineral particles can seed ice crystals in clouds. When those crystals crash into each other, they create the electrical charges that power lightning bolts. Ice crystals also make storms more intense. Rain falls in heavier drops, sometimes even as head-pummeling hailstones the size of baseballs. These intense storms cause more flooding and erosion, yet less long-term water storage, than the drizzles from clouds without ice crystals.

Particles darken the sky in China and India, where people in heavily populated areas burn coal, dung and firewood for cooking and heating. Satellite images suggest that the air over cities holds 20 to 70 times as many cloud-seeding particles as the air over pristine regions, with Asian cities at the higher end. And these images and chemical fingerprinting show Gobi Desert dust and Shanghai smog sometimes mingle with the local particles darkening California and Colorado.

Rangwala, who grew up near Delhi in central India, says the effects of pollution and local land disturbance on the region's rainfall patterns helped inspire him to become a climatologist. He currently works for the Western Water Assessment, a National Oceanic and Atmospheric Administration program based in Boulder, Colo.

His research in the San Juans indicates that dust may be heightening the temperature rise documented in his analysis of dozens of weather and snow stations. The early melting of dusted snow leaves the landscape with less moisture to temper the sun's rays.

Things are even more extreme in the area where he grew up. His hometown of Udaipur, known as the City of Lakes and Palaces, has become a city of empty promises. The many small reservoirs dotting the landscape have failed to fill during most of the past 20 years, Rangwala says. Like Phoenix, Udaipur sits at about 1,000 feet in elevation, ringed by mountains. The area has even begun to resemble the U.S. Southwest, with the cacti that once lurked in the background becoming increasingly prominent. Decades of deforestation of the native teak trees have contributed to the problem, boosting the loads of dust that warm the air and intensify rainfall.

Like the monsoons of the American Southwest, India's summer rains are often accompanied by thunder, lightning and intense downpours. Rangwala says his friends and colleagues back home are concerned because most of their region's rainfall is now coming almost exclusively as intense storms. "When I go back to India, I hear that people have not seen drizzle for a long time," he says. "What we get are these intense events. We don't get enough, and what we get comes in big chunks. The landscape is becoming more like Tucson now."

Melanie Lenart is an environmental scientist and writer whose previous freelance publications include Nature Reports: Climate Change and Landscape Architecture Magazine. *Her work on climate issues includes a 2010 book, Life in the Hothouse: How a Living Planet Survives Climate Change.*

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