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Jeremy Jones rips a line through the Sierra Nevada, an area that's been parched for snow in recent years. Can cloud seeding help quench the thirst? PHOTO: SETH LIGHTCAP

IT'S LATE MARCH IN THE HIGH SIERRA, A TIME WHEN THE 8,600-FOOT RIDGELINE THAT FRANK MCDONOUGH IS STANDING ON WOULD NORMALLY BE COVERED WITH A HEALTHY LAYER OF SPRING CORN. NOT THIS YEAR—AS FAR AS THE EYE CAN SEE, THERE IS MUCH MORE EARTH SHOWING THAN PATCHES OF WHITE. SIERRA-AT-TAHOE SKI RESORT CLOSED A WEEK AGO—THE FIFTH RESORT TO CALL IT A SEASON ALREADY—AND THREE MORE TAHOE RESORTS WILL BE CLOSED BY THE FIRST WEEK OF APRIL. CALIFORNIA IS IN THE MIDST OF ITS WORST DROUGHT EVER.

Ironically, as McDonough gazes out across the naked peaks, he's standing beside a machine that can actually make it snow. It doesn't make snow like the guns that spit shaved ice over groomers—it literally makes real snow fall from the sky. It's called a cloud seeding generator.

But as the name suggests, you first need clouds to seed. And not just any clouds—they must have water drops of a certain temperature that need a little help turning to ice crystals and falling to earth. The seeding agent is silver iodide, an inert chemical compound that is structurally identical to an ice crystal and promotes that formation. Believe it or not, cloud seeding has been around for 75 years but has spent most of that time on the outer fringes of "real" science and largely misunderstood. Everyone from environmentalists to meteorologists have tried to poke holes in its safety and efficacy. It didn't help matters that some of the ways in which seeding has been used have felt like a colossal waste of resources—like the time China tried to blast precipitation out of the sky before the 2008 Beijing Olympics to ensure a dry games.

"The biggest misconception about cloud seeding," McDonough says, "is that people think you can take a bluebird day like today and make it snow."

McDonough is one of the country's foremost cloud seeding scientists, and he often feels like he spends as much time selling seeding as he does on the science. "Most people don't understand how it works. Half the people think it's just a bunch of BS, and the other half think we're polluting," he says. "But when conditions are right, we can put another inch or two of fluffy on these mountains, and we want people to know about it."

The 55-year-old California native sports wraparound shades, an out-of-date Gore-Tex shell, and a handlebar mustache. He speaks with a laidback West Coast drawl, and his confidence comes from the fact that he finally has the science to back him up: The state of Wyoming just completed a 15-million-dollar study over 10 years confirming that cloud seeding can add, on average, 10 percent more snow to an existing storm. This is due in large part to advances in both the machinery and the way we look at weather itself.

Joe Busto loading up a cloud seeding machine with silver iodide, pictured to the right. PHOTO: JEFF DEAN

PHOTO: BEN BIRK

Ag Silver Iodide **I**

MAXIMUM YIELD

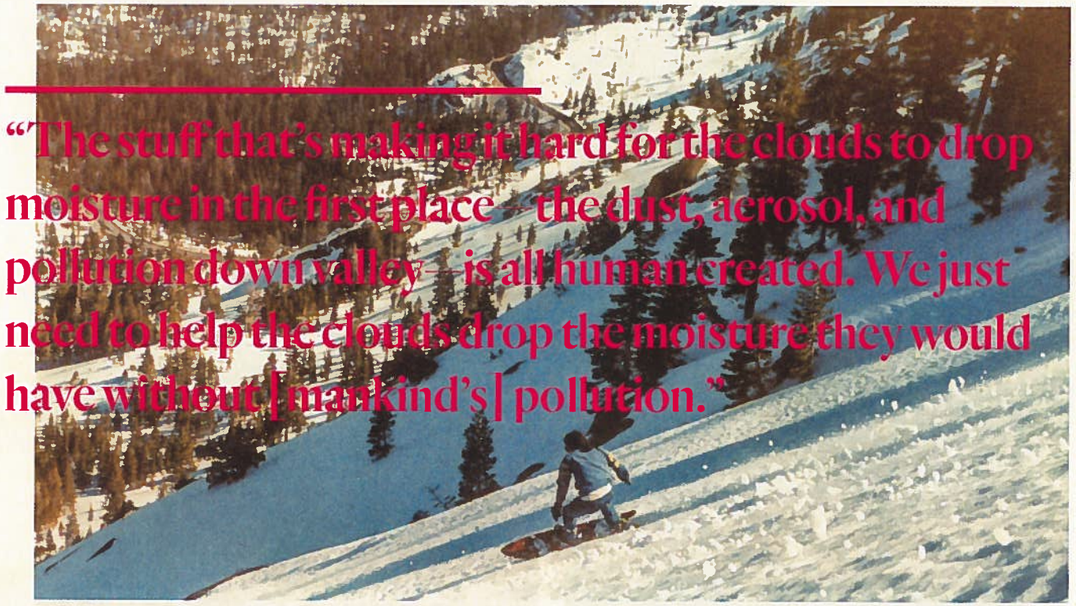
A meteorologist by trade, McDonough is at the sharp end of a major shift in how and where people deploy cloud seeding machines. Desert Research Institute (DRI), the research facility in Reno, Nevada, where McDonough works, has honed seeding to an incredibly exact science that yields maximum potential snowfall using minimal resources. This is obviously great news for power companies like Pacific Gas and Electric Company (PG&E), who have relied on cloud seeding to boost water reserves since 1953, but it also opens the science up to new applications.

"Seeding can now be much more ski-area specific," explains McDonough, as he looks out over Alpine Meadows toward Northstar and Mt. Rose in the distance—all of which sit in the path of the seeding machine he's standing beside at the top of Ward Peak. McDonough says it's now possible to target seeding with more accuracy than ever before and extract enough extra snow from passing clouds that it will actually have an effect on a resort's annual totals.

One major leap forward is the machines themselves. The unit McDonough is standing beside sits directly in front of where Alpine Meadows' Summit Six chairlift dumps you out. The 15-foot-tall machine has a base unit the size of a small U-Haul trailer, with an Army-bunker-strong shell protecting its brain of high-tech electronics from winter weather blasts. In total, there are roughly 100 cloud seeding generators spread throughout California, but only 11 made by DRI. Some, like this one, are easily accessible, while many are deep in the backcountry, only reachable by snowmobile or a stiff hike. No matter, a DRI machine can be turned on with the click of a mouse from a Starbucks.

Sitting inside the Ward Peak generator, pecking away at a laptop that operates the entire seeding process, is Jeff Dean. A former backcountry ski patroller, Dean is DRI's principal research technician. He not only helps design the generators, but also maintains the entire network throughout the winter. For Dean, cloud seeding is much more than just a bunch of weather models and chemical formulas. "We usually go out into the field or take days off as soon as the storm finishes," he says with a giant grin. "I get to seed it and then I get to go out and ride it."

"Seeding can now be much more ski-area specific"



"The stuff that's making it hard for the clouds to drop moisture in the first place—the dust, aerosol, and pollution down valley—is all human created. We just need to help the clouds drop the moisture they would have without [mankind's] pollution."

Frank McDonough back in the early days of Tahoe snowboarding before cloud seeding was necessary. PHOTO: JERRY MCDONOUGH

SOWING THE SEEDS

The year Frank McDonough strapped into a snowboard for the very first time, it had skegs and a rope attached to the nose. It was the '82/'83 season—an El Niño year—and he was living out near the central coast of California. "There was a storm over Horse Mountain that delivered like eight feet overnight," he remembers. "It was unbelievable—nice, wet, safe snow. I still have a picture of my brother jumping off a rock, holding the rope."

McDonough and his brothers became obsessed with snowboarding, and it wasn't long before they moved to Tahoe to join others who were just discovering the sport. This was at a time when resort riding wasn't even an option. "We would ski the resorts but hike with our snowboards. We hiked all over, dropped everything down in the valley below Red Dog and Ward Peak. All we ever rode was powder."

McDonough says he was always a bit of a weather geek and eventually turned it into a career by getting his masters in atmospheric science and taking a job in Colorado as the lead scientist on an aircraft icing research project. McDonough lived and breathed ice crystals, seeking to understand exactly how they formed and, more crucially, how to keep them from forming on the wings of an airplane.

Meanwhile, cloud seeding had been around nearly 50 years at this point. It had been discovered by accident in the mid-'40s when a small group of researchers—including Nobel Prize-winning atmospheric scientist Bernard Vonnegut (brother of the famous novelist Kurt)—were trying to figure out ways to extract moisture from clouds using a small room called a "cold box." They struggled to get the room cold enough, so they brought in dry ice to drop the temperature further—to their surprise, the dry ice ended up being the agent that finally caused the moisture to form. Silver iodide was later discovered to be a more efficient agent. "You're giving the clouds a little kick," McDonough explains. "'Here are some baby ice crystals. Do your thing.'"

Its application was immediately obvious in the drought-prone West. California became an early adopter, and it would eventually spread to Nevada, Utah, and Wyoming (cloud seeding is currently in use in 10 US states). But it remained so under the radar that few studies were done to measure its effectiveness, and there was almost zero government funding for it.

As the years went by, scientists noodled away in what research institutes would call their "weather modification program," making it sound more like something a Bond villain would use to hold the world ransom than a potential solution to water problems. Seeding programs all over the country were reporting increased precipitation, but it was largely anecdotal.

"I had heard about seeding when I lived in Colorado," McDonough says. "But I didn't know how extensive it was. I heard they were doing it at Vail."

It's true. By the 1970s, resorts began to take notice of seeding's potential to augment snowpack, tack extra days onto the end of a season, bolster their reported "annual total," and in turn add customers. But Vail's seeding program remained privately funded and somewhat secretive, as they weren't eager to share details about anything that might give them a competitive edge. The truth is, it was hard to say whether Vail was gaining a competitive edge at all or simply blowing 150,000 dollars a year on snake oil.

Meanwhile, throughout the '80s and '90s, Deserts Research Institute, under the guidance of legendary seeding scientist Arlen Huggins, was honing the science even further, developing the perfect silver iodide solution, figuring out whether seeding generators should sit in valleys or atop ridges, and exactly how the silver might impact local ecology. Over the next 20 years, DRI became instrumental in designing the next-gen seeding generator that used a perfectly calibrated amount of silver, and they began using the latest meteorological tools to better understand when to seed and when not to.

The results of the Wyoming study created something of a perfect storm—an alignment of conditions that made cynics curious and turned the curious into converts. The science, scientists, and technology seemed to have come into its own.

Meanwhile, McDonough probably knew more about the right and wrong conditions for seeding than anyone else in the country, given his prior work with ice crystals. For a powder hound like him, using his superpowers to help top off reservoirs and drop more snow onto the mountains he loved to ride was destiny.

REMOTE CONTROL

Ironically, cloud seeding's biggest advocate may also be its biggest critic. Joe Busto is the weather modification program coordinator with the Colorado Water Conservation Board (CWCB). Early in his career, he believed in cloud seeding but was unwilling to stake his reputation on it until the science matured. "I hate '70s-style seeding," Busto says.

Busto feels that inefficient seeding is exactly what's obscuring its path into the future. He only became its most vocal advocate once the science started catching up and DRI began producing a superior machine. He recognized that the time had come to develop new seeding programs all over the US—for power companies and ski resorts.

Naturally, as the cloud seeding conversation got louder, so did the skeptics, particularly the environmentalists who were concerned that the silver iodide that gets shot up into the atmosphere would end up in surrounding water and soil. But the study went a long way in placating people's fears, proving that residual amounts were trace—20 parts per trillion—in most cases. It was almost undetectable, given the existence of naturally occurring silver in the soil. This was a fact most seeding scientists already knew but have always had trouble proving.

Some ecologists simply felt that man should not be messing with Mother Nature. McDonough says it's way too late for that: "The stuff that's making it hard for the clouds to drop moisture in the first place—the dust, aerosol, and pollution down valley—is all human created. We just need to help the clouds drop the moisture they would have without [mankind's] pollution."

Defending cloud seeding's environmental impact was the easy part. The hard part would be convincing existing cloud seeding programs that what they were doing was grossly inefficient and a huge waste of money.

Busto, 48, is also a longtime snowboarder and, like McDonough, was there at the birth of the sport. He says the old way of doing things could hurt seeding's chances of succeeding on a larger scale. "Silver iodide is very expensive," he says. "Topping up one machine costs 12,000 dollars; it's 30,000 dollars to run one for a year.

"Some ski area programs simply aren't keeping up with the science. People are basically turning the generators on before a storm hits, leaving it on all night, and then turning it off in the morning—even if there aren't clouds all night."

DRI's machines, on the other hand, are operated remotely and with more precision. McDonough and his team work round the clock in 12-hour shifts, watching the weather models, turning individual seeding generators on when conditions are right and then off again when they're not.

DRI's machines are what helped Busto get the attention of Doug Laraby, planning director for Winter Park Resort in Colorado. Laraby attended a talk Busto had given at the National Ski Areas Association, and the two of them struck up a conversation about starting a seeding program at the resort, to be co-funded by Denver Water. In 2009, Winter Park committed to posting two DRI cloud seeding generators along its ridges, one of which is the highest in the country at 9,500 feet.

"The new machines were a turning point for us," Laraby says. "Having someone who's watching our weather and turning them on and off based on the conditions is so much more efficient. It's not going to make or break a season, but it's icing on the cake.

"Even if you get five inches and another resort nearby only gets four, when you're wondering where to go [ride] that day, you might go for more snow."

Both McDonough and Busto go to great lengths to not overstate the capabilities of cloud seeding. "You have to really get in there and understand the weather for an area before you start cloud seeding," McDonough explains. "We pride ourselves on doing it as precisely as possible—we don't want to put one extra bit of silver in the air if we can help it. We want to make sure the people who are funding us to make snow are getting their money's worth."

Desert Research Institute's 200-million-dollar facility sits atop a hill along a two-lane road that winds through the outskirts of Reno. In McDonough's office are two computer screens that track current and future weather movement, honing in on clouds with those "super-cooled" water droplets needed. He cross-references with things like pilot reports of icing and the appearance of rime ice on backcountry webcams.

While you can't actually see cloud seeding in the air, you can see it on radar—visual proof that each time you turn on that generator, something pretty remarkable is happening. "Seeding has a signature," McDonough says. "It's a slightly different-looking cloud, with crystals that bounce the light a little differently because they're bigger than in clouds that aren't seeded.

"I once saw a cloud seeding plane go in and paint a stripe of silver iodide at about 16,000 feet. Afterward, I watched the whole area get hit with snow on-screen through increased radar echo." (Airplane seeding has proven to be extremely dangerous because it requires pilots to fly in the exact sort of icing-prone conditions they are trained to avoid).

Across town from DRI, the old University of Nevada, Reno Job Corps facility is where technician Jeff Dean and his team build the latest generation of remote-operated seeding machines. Out front stands a six-pack of these canons, lined up like soldiers ready for action. The steel housing units are painted camouflage to minimize visual impact; a 10-foot tower rises from the top of each box, topped of with a burner drum that reduces the silver molecules to the right size before they're shot up into the atmosphere. Inside is one of Dean's crew, Jesse Juchtzer, a former Navy aviation mechanic with a degree in environmental science and ecology. Juchtzer grew up competing for his local ski team in Reno and then switched to snowboarding after high school. He's making small tweaks and adjustments to the fleet before storing them away for the summer.

For Juchtzer, the most remarkable thing about cloud seeding is simply how few people are aware of it. "This is what blew my mind," he says. "I went to a conference in Tahoe, where scientists were predicting what the snowpack might be like over the next hundred years. I said, 'What about cloud seeding?' They said, 'What's cloud seeding?'"

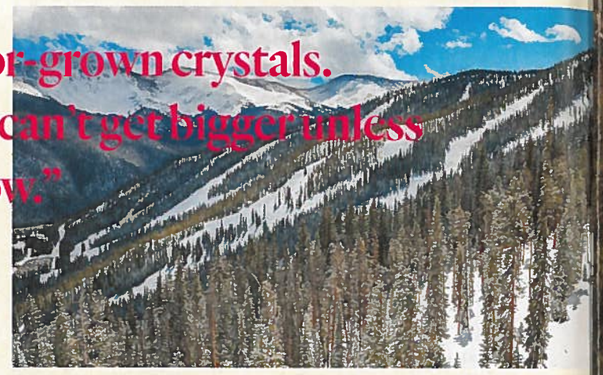
Crystal Clear: Cloud Seeding vs. Snow Guns

Cloud Seeding
The snow that falls from seeded clouds is basically real snow—six-sided flakes with moisture content similar to naturally occurring flakes in a particular area. Seeded flakes can even be slightly bigger, due to the salt, which attracts more moisture.

Snow Guns
Snow guns shoot water droplets that are so small they freeze when they hit cold air. But it falls to the ground as a tiny ball of ice. Guns are great for targeting specific trails and ice balls are good for base coverage, but they lack the fluffiness of flakes.

Ready for action, the latest generation of remote-operated seeding machines stands at attention in Reno, Nevada. PHOTO: BEN BIRK

Winter Park, Colorado.
PHOTO: CHRIS WELLHAUSEN



"Cloud seeding snow is vapor-grown crystals. They're fluffy. An ice crystal can't get bigger unless it's in a cloud. That's real snow."

THE GOOD FIGHT

All told, there isn't so much a hot debate about cloud seeding as there is a struggle for validation. Busto admits that indifference is a major hurdle—convincing people that 10 percent more snow can really make a difference.

The ski and snowboard industry is largely unaware or unmoved. Even pros associated with Protect Our Winters (POW) like Jeremy Jones, as well as Ryland Bell and Gretchen Bleiler, are unfamiliar with how it works and where it's being done. Perennial eco-warrior Patagonia also has zero official stance on cloud seeding. Even despite the measurable increase in snow at Winter Park, Doug Laraby admits that the average skier or snowboarder is largely unaware of the seeding done there.

Sadly, it took a drought of epic proportions for more people to take notice. The silver lining is that this common enemy has more folks willing to share the fight. These days, most seeding programs are at least partially funded by water programs, including DRI's. "My goal is to get ski areas and water managers to truly work together," Busto says. "But it's two very different corporate cultures: the CWCB has board meetings that are publicly recorded; ski resorts don't. Vail's seeding program has been the same since 1976. My mission is to make sure industry-standard equipment is in operation."

Busto says Winter Park was the first resort to "pull its head out and do it right," McDonough agrees: "Winter Park is a great project. The ski area is paying for part of it, and Denver Water is paying for the rest. There is evidence that Winter Park is doing a little better than surrounding mountains that aren't seeded. And when it runs off, Denver gets the water. It's win-win."

Busto and McDonough's final hurdle seems to be those who think it simply isn't worth it. And with snowmaking technology also getting better, why bother with seeding at all? Better snow and a better base, says McDonough.

"Snowmaking blasts water through a hose that atomizes it into tiny little drops that get frozen. But they're growing ice balls, which aren't all that fun to ski on, and you can only hit areas where the nozzle is pointing.

"Cloud seeding snow is vapor-grown crystals. They're fluffy. An ice crystal can't get bigger unless it's in a cloud. That's real snow."

Standing atop Ward Peak at Alpine Meadows, the future of cloud seeding is obvious. It's a warm, cloudless day. The seeding generator is in sleep mode and, from the looks of the weather forecasts, likely to stay that way for a while. But the weather models do show a tiny system that may or may not move through the Sierra in about a week. Herein lies the true value of cloud seeding: If mountain weather systems are going to be small and infrequent—as they were last winter and seem to be every few years—that extra 10 percent we can get from smart seeding becomes more important than ever.

Jeff Dean scrapes a bit of sulfur residue from the outside of his generator, closes up his laptop, and locks the heavy steel door on the housing. It's ready for action as the last gasps of Winter 2015 sputter into April. "Wherever there are mountains that need water, people are cloud seeding," Dean says. "Water is gold. Most Western states have cloud seeding now, and I wouldn't mind doubling what we do. And I think we're on our way—we have the reputation."

As Dean points out, cloud seeding will always be about water—squeezing out much-needed inches at a time when every drop counts. But cloud seeding water will always come from snowpack. So as long as guys like Frank McDonough and Joe Busto keep fighting the good fight, there's a good chance that, in the not-too-distant future, your local resort will be able to stay open just a little longer than it would have. And there's a good chance that each storm will bring, as McDonough likes to say, just a couple more inches of fluffy.

Colorado Resorts Particpating in Cloud Seeding:

- Winter Park
- Vail
- Beaver Creek
- Keystone
- Breckenridge
- Powderhorn
- Crested Butte
- Telluride
- Purgatory

Cloud control to Major Tom...
PHOTO: BEN BIRK