SCIENTIFIC AMERICAN®

Can Meadows Rescue the Planet from CO2?

An unusual research project is determining whether restoring California's meadows can reduce atmospheric carbon dioxide

By Jane Braxton Little on May 11, 2017

The record piles of snow across California's Sierra Nevada are melting away, exposing once again its breathtaking alpine meadows. As temperatures warm the moist soil, the meadows quicken, cycling carbon from the ground into the atmosphere and back again in a pattern essential to the planet's health. Scientists and land managers are heading into the mountains to measure the greenhouse gas activity at 16 hand-picked meadows—some recently restored, others degraded from a century of grazing and logging.

The four-year study is part of California's pioneering effort to reduce carbon emissions. The project is designed to determine whether restored meadows hold more carbon than those that have been degraded. The outcome could prove pivotal for California and the planet. Worldwide, soils store three times more carbon than vegetation and the atmosphere combined. If the research shows restored meadows improve carbon storage, it could stimulate meadow restoration around the world.

The $4.8-million project has an unusual twist, too. It is funded by the California Air Resources Board, which wants to know if restored meadows can hold enough tonnage of carbon dioxide equivalents, per acre per year, to qualify as carbon credits in California's cap-and-trade market. "It's kind of geeky but we're poised to do something that's never been done with alpine meadows," says Mark Drew, Sierra Headwaters director at California Trout, who is coordinating the work.

Meadows are new to soil carbon research. Carbon enters the soil as plants use solar energy to draw carbon dioxide from the atmosphere and make their own food. More enters the ground when plants die and are decomposed by microbes. And yet living plant roots expel carbon dioxide, and so do microbes as they decompose the dead plant matter, creating a cycle of carbon uptake and emission by soil. It is common for agricultural land to lose a fair portion of its original carbon stock as it is relentlessly farmed—as much as 50 to 70 percent, according to several estimates. Scientists suspect meadows may lose carbon as well, especially when they are degraded by logging and grazing activities that compact soils, erode streams and deplete native plants and animals.

Sky Parlor Meadow in Tulare, California. *Credit: Miguel Vieira Flickr (CC BY 2.0)*

Some scientists also think global warming itself is changing soil carbon stocks. A December study published in Nature, led by Thomas Crowther at Netherlands Institute of Ecology, found rising temperatures are stimulating a net loss of soil carbon to the atmosphere. Warmer soils accelerate the flux, sending more carbon into the ground and more carbon dioxide back out into the atmosphere. As warmth increases microbial activity, decomposition and respiration outpace photosynthesis, particularly in the world's colder places. "That's when the losses start to happen," Crowther says. The changes could drive a carbon–climate feedback loop that could accelerate climate change.

Drew was already starting to collaborate with several meadow restoration groups in 2014, when the Air Resources Board announced funding to study carbon flux in Sierra meadows. Rather than compete for small pots of money, the various stakeholders decided to work together—PhD scientists side by side with ranchers and landowners. Together they could build a database far larger than any one project could, Drew says.

The group already knew meadow restoration—usually done with heavy equipment to fill braided channels and re-create functioning floodplains—has well-documented ecosystem benefits. Returning streams to their natural meanders and raising the water table rejuvenates habitat for golden trout, willow flycatchers and other endangered species. Restoring

SCIENTIFIC AMERICAN®

Morning clouds over the Sierra Mountains in Bishop, California. *Credit: David H. Carriere Getty Images*

meadows also improves their capacity to store and release water, a boon to a state that depends on the Sierra region for more than 60 percent of its water supply. Spurred by Air Board funding, the meadow partners set out to see what restoration could do for carbon storage as well.

The research covers meadows from the base of Lassen Peak in the north to areas nearer to Los Angeles. The meadows range in elevation from 3,045 to nearly 8,700 feet; they include granitic, volcanic and metamorphic soils. A critical facet of the partnership is developing precise procedures for when and how to measure and analyze meadow greenhouse gases. Although scientists have established protocols for monitoring carbon flux in forests and wetlands, none exist for alpine meadows. “We’re the guinea pigs,” Drew says.

Work has just begun and will continue until winter closes access. The data collection begins with pushing an eight-inch segment of PVC pipe into the ground vertically to seal off a small segment of meadow, then capping the cylindrical chamber. A monitor pokes a syringe into a tiny hole in the cap, drawing a sample of whatever meadow gases are captured inside. By taking three samples 15 minutes apart repeatedly over several months scientists can compare the ambient air with gases coming directly out of the meadow. The rate of change in the concentration of gases determines the soil’s CO2 emission rate. The researchers are also monitoring soil carbon by extracting core samples. Comparing the data from restored meadows with geographically similar degraded sites will show the effects of restoration.

The researchers have a hint of what they might find from a limited study conducted by the University of Nevada, Reno (U.N.R.). Scientists collected soil samples at seven meadows in the northern Sierra restored between 2001 and 2016, pairing restored sites with similar, adjacent unrestored sites. The preliminary results found an average of 20 percent more soil carbon in restored meadows, with one site recording an increase of over 80 percent. Meadows immediately begin storing carbon following restoration, with significant increases over 15 years, says Cody Reed, a research assistant working with Ben Sullivan, a U.N.R. soil scientist and assistant professor. The investigation seems to show restored meadows add soil carbon and also slow losses to the atmosphere.

Another limited study looked at the effects of water in meadow soils. Steve Hart, an ecology professor at University of California, Merced, and Joseph Blankinship, assistant professor of microbial biogeochemistry at the University of Arizona, researched a Sierra meadow to understand how water affects the fluxes of carbon dioxide, methane and nitrous oxide. What they found surprised them: Carbon dioxide emissions were unaffected by soil moisture content, and methane sequestration was prevalent, particularly on the dry side of wet meadow. The 2014 study also found plant species richness and soil carbon concentration appeared more important than soil moisture in explaining carbon fluxes.

It is too soon to know if these results will be replicated on the larger Sierra-wide scale. With a full year of research already logged, Drew and his partners are digging in to a new season of fieldwork. A finding of dramatically increased soil carbon in restored meadows would have a limited effect globally because such large forces are at work. But the gain could be an important, added payoff for restoring these landscapes. The Sierra Meadows Partnership could also serve as a model to others working in very different landscapes that hold the potential to have a much greater effect on the carbon equation, Hart says. And if restored meadows do indeed hold significantly more carbon, then they could play a role in California's carbon market. The Sierra partners have until 2019 to present their results. “We’re poised to do something really unique,” Drew says. “Let's see where it takes us.”

CALIFORNIA TROUT
FISH · WATER · PEOPLE

Mark Drew, PhD
Director, Sierra Headwaters Region
(760) 924-1008
mdrew@caltrout.org