JIM NICKLES/USGS

A SINK FOR CARBON DIOXIDE

'CARBON-CAPTURE FARM' rebuilds wetlands, sequesters the greenhouse gas in the California Delta

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IN THE ENVIRONMENTALLY precarious delta area near Northern California's San Joaquin Valley, a small project with implications for environmental renewal is making big news. Its premise is simple: submerge a farmed, soil-depleted section of land in water and strew it with a liberal planting of native tules, which are a type of bulrush. In one growing season, it will have turned into a lush marsh that sucks the greenhouse gas carbon dioxide out of the air.

On a patch of land known as the "carbon-capture farm" on a section of Twitchell Island in the California Delta, scientists using this approach have succeeded in building up to 2 feet of peat soil on previously drained terrain. Recently, the project took on an environmentally attractive dimension, when the researchers discovered the farm sequesters atmospheric CO_2 at rates greater than other ecosystems.

A few months ago, the California Department of Water Resources took note and ponied up $12.3 million to expand the project, to be used over three years. A handful of scientists who once spent their days monitoring plant decomposition rates and gas exchange now suddenly find themselves with a research windfall. They are planning to quadruple their farm size and are eyeing carbon-capture farming as a potential source of carbon credits for industry.

The delta area has long been plagued by major environmental problems. Its system of waterways and islands, the site of intensive farming for more than 150

WORKING THE LAND Carbon-capture farms, such as this one in the California Delta, may be a future source of carbon credits.

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years, is more than 20 feet below sea level and continues to lose an inch or two of soil each year. The delta is tenuously protected from an influx of salty ocean water by a system of old levees that are in danger of breaking. In 2006, heavy rains overtopped a levee, illustrating the potential danger of flooding and saltwater contamination from the ocean.

In addition, the freshwater that flows in from the nearby Sierra Nevada mountains is tainted with, among other things, mercury, a relic from mercury use in gold mining during the gold rush days of the 1800s.

Ten years ago, scientists' main concern for the delta was the loss of soil, also known as subsidence. A preliminary experiment on a small plot of land showed that soil is best

AMONG THE TULE Miller is a lead scientist who analyzes the growth and decomposition of plants for the farm project.

able to preserve carbon if it's covered in water all the time.

"The question was, 'What's the best water depth?'" says Robin Miller, a biogeochemist and lead scientist for the carbon-capture farm project. Besides Miller, the new project now includes scientists from the U.S. Geological Survey (USGS); the University of California, Davis; UC Berkeley; and the University of New Hampshire.

Soil cores taken from delta islands in the 1970s showed that in the past 7,000 or so years, the area was populated primarily by tules and reeds.

So the researchers selected two 7-acre plots, submerged them in water, planted tule, and let other native plants, such as cattail, take hold as well. They covered one plot with about a foot of water, the other with about two feet. A system of inflow and outflow pipes maintained the correct water depth. Under these submerged conditions, the grasses die back and regrow each year while microbes decompose the dead vegetation.

A DECADE LATER, where the land was once dry and bare, it is now almost junglelike—thick with 10-foot-tall slender fronds—and home to bittern, a species of wading bird, and raccoons. The air is vegetal and moist, the soil below is squishy. Tiny fish swarm in large ponds.

The results exceeded expectations: In the more deeply submerged of the two plots, soil levels increased by 2 feet. By contrast, the corn fields just adjacent to the carbon-capture farm are still subsiding.

"The types of accretion rates in the literature are on the order of a millimeter per year," Miller notes. "We're getting several centimeters a year—that's a whole order-of-magnitude difference."

The soil-building effect appears to stem from a gradual slowing of plant decomposition combined with fast wetland growth. For example, in the first year, 90% of the plants completely decomposed, but several years later, only 70% decomposed. The process builds on itself, helped along by the cooler temperatures and lack of oxygen in the water-laden environment.

But it was the large carbon sequestration results that pushed the project into the limelight. All plants take up CO_2 during photosynthesis, but these wetlands seem to do it better. In fact, measurements indicate that if an area the size of the delta were converted into carbon-capture farms, the amount of CO_2 taken up would be the "equivalent of turning all the SUVs in California into hybrids," says Kimberly A. Taylor, a scientist with USGS.

With global attention now focused on human-produced greenhouse gases, interest in carbon sequestration has grown ever greater. For example, industries are looking to take advantage of "carbon credits," investments in technologies that remove carbon from the atmosphere, to offset carbon the industries put out.

The carbon-capture-farming researchers say that, although they've demonstrated the farm's inherent capabilities, they still don't fully understand why it works so well.

"What's causing the biogeochemistry that's creating these positive results?" Taylor asks. "If you were going to be a carbon-capture farmer, how would you manage the water system to re-create those types of conditions?"

And the system is not without its potential pitfalls. A delicate balance must be struck with the complex chemistry of microbes and their effect on the environment. When microbes decompose plants in an aerobic environment, they produce CO_2 and water. But in an anaerobic environment, they can produce methane, a greenhouse gas 20 times more potent than CO_2. But the special combination of marsh plants and the right amount of water seems to produce a net greenhouse gas reducing effect, sequestering sufficient CO_2 to more than compensate for production of other greenhouse gases.

Pollutants such as methylmercury, a toxic cation produced when microbes encounter mercury, and dissolved organic carbon compounds also present problems unique to this area of California and could be produced in farm areas, says Roger Fujii, director of the carbon-capture farm project.

Those are issues that will be explored in more detail in the coming few years on a new 400-acre carbon-capture farm that's being planned a short distance away from the current one. The carbon-capture farm "is a great system to pick apart the processes and complexities" of using land and water to build soil and remediate greenhouse gases, Fujii says. ■

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FARM ANALYSIS Biogeochemist Jacob Fleck (left), who studies organic matter interactions with mercury, chats with lead field staff member Peter Dileanis, who coordinates field sampling.