Climate scientists focus on extracting the carbon already in our air

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For decades, most of the strategizing about how to slow down climate change has focused on cutting emissions of carbon dioxide and other greenhouse gases, mainly by shifting away from fossil fuels. Other proposals range from reducing meat consumption (cattle belch massive quantities of methane, a potent greenhouse gas) to curtailment of chlorofluorocarbons (compounds that both retain heat and destroy atmospheric ozone) in refrigerants and aerosols.

Carbon reduction is still a priority. But it's clear from the palaver at the

United Nations Climate Change Conference underway near Paris that scientists and regulators are placing increased emphasis on carbon removal and sequestration: stripping CO2 or other greenhouse gases from the air and stashing them in a variety of solid forms, including subterranean mineral compounds, trees—even grass and marine algae.

Why the shift? Simply put, it looks like cutting human-generated emissions alone won't be enough to keep Earth from warming more than the 2°C limit established as a goal by the UN. By scouring gaseous carbon from the atmosphere and locking it up in plants and rocks, the thinking goes, we can keep the element from performing its global warming mischief.

UC Berkeley is focusing on the carbon sequestration mission, as evidenced by its recent climate change initiatives. Indeed, the university is a primary supporter of the Center for Carbon Removal, a subsidiary of the Berkeley Energy and Climate Institute. As its name suggests, the center is devoted to identifying and implementing the most efficient means for taking carbon from the atmosphere and transferring it to places where it can do no harm.

Reached at the Paris Climate Change Conference, Noah Deich, the executive director for the Center for Carbon Removal, ruminated on the directions planetary-scale carbon removal schemes might take. The list of proposals is extensive and growing, he notes, but they generally fall within two "capture pathways:" biological and chemical.

Biological carbon schemes largely rely on natural plant photosynthesis to snare carbon from the air. Though Deich observes this is an essentially "carbon-neutral" phenomenon—plants use carbon from the air to build vascular tissue, but the carbon is released back into the atmosphere when the plants die and decompose—the process nevertheless can be tweaked to lock up large amounts of carbon for long periods of time. For example, you can literally farm for carbon.

"Certain agricultural techniques (can) increase plant stocks or enhance the ability of soils to uptake and store carbon," Deich writes. Such practices include conservation tillage, cover cropping, crop rotation compost application and rotational livestock grazing. All can increase the organic material—that is to say, carbon—in the soil in the form of crop residues, roots, worms, bacteria and other biota, and animal wastes.

Restoring ecosystems—particularly wetlands—is a promising avenue for carbon removal.

"Many ecosystems provide natural carbon sinks, but they (may have been) degraded over time by agricultural and urban expansion," Deich explains. "Restoring carbon-storing ecosystems like peatlands and mangroves can aid in mitigating climate change, while also providing numerous other ecosystem services (such as clean water, open space, wildlife habitat and fisheries enhancement)."

Another encouraging option is reforestation. The extant prime example is Reducing Emissions from Deforestation and Forest Degradation (REDD), a 2005 initiative by the United Nations Framework Convention on Climate Change. While its results have been mixed, the thinking is that since deforestation may account for 10 to 30 percent of atmospheric carbon emissions, planting lots and lots (and lots) of trees may reverse or at least stabilize accumulating greenhouse gases.

But merely stopping ongoing deforestation isn't enough; we have to plant more trees than we are cutting. "Avoided deforestation is not considered a carbon removal technique because it only maintains rather than enhances natural carbon sinks," Deich cautions.

There also are other, more exotic, biological approaches. Biochar, for example, is created by heating biomass such as wood and crop residues at high temperatures in the absence of oxygen. Climate change activists are attracted by stability: It decomposes very slowly, releasing its carbon over decades or centuries, rather than in months or years, as is the case with untreated biomass. Biochar can be used to amend farming soil, for land reclamation, or as filters for waste treatment.

Deich also is bullish on bioenergy projects that are coupled with carbon capture and storage systems. Traditional biomass projects burn materials such as waste wood chips or almond hulls to produce electricity, but such facilities sequester little if any carbon, because it goes up the smokestacks and into the atmosphere. But it's possible to hook such power plants up to systems that capture the CO_2 in the exhaust gases and stick it underground or combine it with cements or plastics for commercial use.

Such systems already have been developed for fossil fuel plants, observes Deich, but combining them with biomass plants yields superior carbon storage dividends. The carbon in waste wood and nut hulls is derived from atmospheric sources, not dug from the ground; fossil fuels add to existing atmospheric carbon, while biomass essentially is "carbon neutral"—it just recycles the carbon that plants derive from the air back into the atmosphere.

Chemical carbon storage offers somewhat more limited options, involving two basic approaches.

"Direct air capture and storage includes technologies that can capture industrial-scale quantities of CO_2 from ambient air using solvents, filters or other methods," Deich notes. But there's an inherent drawback: "Direct air capture systems are energy consuming—not energy generating—so they generate net-negative emissions only when the sequestered CO_2 is greater than the CO_2 emitted to power the system."

Mineral capture and storage, on the other hand, is a passive process that exploits the natural CO_2 sequestering qualities of some minerals, such as silicates. By extracting, crushing and spreading such minerals over large areas, Deich maintains that significant quantities of CO_2 could be captured and stored.

The carbon storage field is still young, and there are other approaches worth exploring. Some have the potential to lock up massive quantities of carbon, but pose significant risks. Ocean fertilization, for example, involves spreading powdered iron over vast areas of the sea. This would cause huge algae blooms, which in turn would lock up megatons or more of carbon—but could also accelerate ocean acidification, which could devastate a wide array of marine species. "With greater incentives," Deich contends, "novel and disruptive carbon removal solutions have the potential to emerge." Here's hoping.

For all of the University of California's support of climate change solutions, Deich thinks the university could—and should—do more:

"Cal should do everything it can to reduce (its own) emissions to zero as quickly as possible. Renewable energy, energy efficiency, transport electrification and land-based carbon-sequestration should be priorities. Cal should also help other large organizations take bold climate action, communicate to industry and policy leaders that our climate ambition can and should be greater than it is today, and (generally) support more research into climate solutions."

Provided by University of California - Berkeley

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