Chapter 10 – Responses

Solutions.

- *Tree planting worldwide* – 1/5th *the answer*.

Professor Philips calculates that tree planting worldwide can only at most be 1/5th the solution to the CO_2 problem. Selection of species of plants and trees more efficient at photosynthesis than the average, or genetic modification of trees to produce more intense absorption of CO_2 could increase this proportion.

For instance, a recent study by German researchers presents the possibility that a significant percentage of atmospheric CO_2 could potentially be removed by planting millions of acres of a hardy little shrub known as *Jatropha curcas*, or the Barbados nut, in dry, coastal areas.

But other experts raised doubts about the study's ambitious projections, questioning whether the Barbados nut would be able to grow well in sandy desert soils and absorb the quantity of carbon their models predict.

The researchers behind the study say Barbados nut plantations could help to mitigate the local effects of global warming in desert areas, causing a decrease in average temperature and an increase in precipitation. If a large enough portion of the Earth were blanketed with carbon farms, they say, these local effects could become global, capturing between 17 and 25 metric tons of CO_2 per hectare each year over a 20-year period.

"All the other techniques we know about just prevent emission, nothing else," said lead author Klaus Becker of the University of Hohenheim in Stuttgart, Germany. "Only plants are able to extract carbon dioxide from the air."

The study, published in the journal *Earth System Dynamics*, states that if 730 million hectares of land – an area about three-quarters the size of the United States – were devoted to this method of carbon farming, the current trend of rising atmospheric CO_2 levels could be halted.

Carbon farms would not compete with food production if they were concentrated in dry coastal areas, the researchers said. In their scenario, oceanside desalination plants, partially powered by biomass harvested from the plantations themselves, provide a low-emissions irrigation method.

The study states that the Barbados nut is uniquely suited to growing in regions inhospitable to other crops. The plant, which produces a nonedible seed that can be used to create biodiesel, is comfortable growing at temperatures exceeding 38 degrees Celsius. It can also withstand high levels of contamination in the soil, making wastewater another potential source for irrigation.

Additionally, the plant grows rapidly and develops "pretty large roots below the soil, which is important for carbon binding," said co-author Volker Wulfmeyer, also of the University of Hohenheim. As part of their research, Wulfmeyer and Becker traveled to a Barbados nut plantation in Luxor, Egypt, to collect physical samples from the plants to estimate their carbon-storing potential.

There are about 1 billion hectares of desert land in coastal areas that could be used for Barbados nut plantations, the researchers estimate, located in countries such as Mexico, Namibia, Saudi Arabia and Oman. If the entirety of this land were used for carbon farming, the study found, atmospheric carbon dioxide could be reduced by 17.5 parts per million over two decades, or 16.6 percent of the CO_2 increase since the start of the Industrial Revolution.

But less ambitious projects may also have an impact. Using models, the researchers projected that 100-square-kilometer plantations in Oman and Mexico's Sonoran Desert could cause temperatures to fall by more than 1 degree Celsius. The model also saw a precipitation increase of 11 millimeters per year in Oman and 30 millimeters per year in the Sonoran.

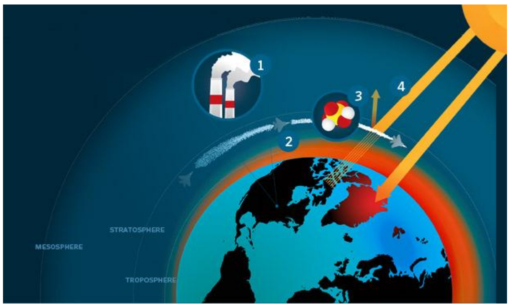
Paradoxically, this is because plantations are darker than the surrounding desert, explained Wulfmeyer, retaining more heat during the daytime. As a result, a low-pressure system develops over the carbon farm, causing changes in wind patterns that allow clouds to develop and precipitation to increase.

Mitigating global warming on a more local scale should be a big incentive for countries to back large plantations, Wulfmeyer said: "The technology is there to do this, but it needs some enthusiasm and some idealism and some more knowledge in the countries before it can be realized."

The cost of carbon farming is comparable to the costs associated with other carbon capture and storage technologies, the study asserts. The researchers calculated that the total cost for a plantation would be between €42 and €63 per ton of carbon, or between about $55 and $85. The estimated cost of carbon capture technology varies widely, but the nonprofit Center for Climate and Energy Solutions pegs it between $36 and $81, depending on the emissions source.

There have been earlier disappointments with Barbados nut farms in Africa, said Meine van Noordwijk, chief science adviser for the World Agroforestry Center in Bogor, Indonesia, who questions the growth rate and the atmospheric carbon capture rate hypothesized by the study's authors, calling the estimated carbon price of the plantations a "substantial underestimate. We are not talking about trees that create substantive, high-density woody biomass, but about a plant with a shrubby growth habit and a long track record of deceiving farmers with yield potentials that are not being realized. Even with the abundance of water, the nutrient storage in sandy desert soil is low, and bringing in the nutrient supply to support high growth rates has high energy costs if nitrogenous fertilizer is used." He added, "The estimated carbon price of this option already indicates that there are far better opportunities for reducing ongoing emissions from peatland use and deforestation."

- *Injecting SO_2 into the stratosphere*.

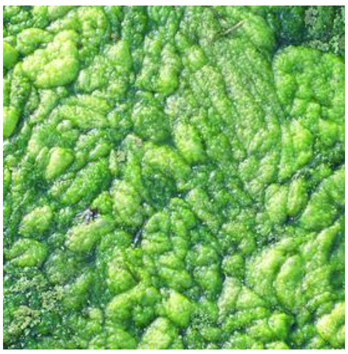


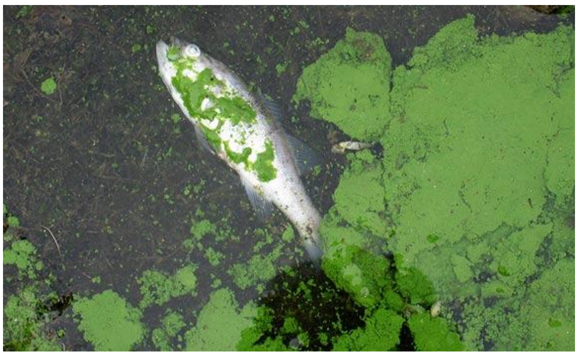
A 2006 essay in the journal *Climatic Change* by the atmospheric chemist Paul Crutzen, who shares a 1995 Nobel Prize for work on ozone formation and decomposition, says the continuing failure of governments to move on global warming makes open discussion of geoengineering essential. "The very best would be if emissions of the greenhouse gases could be reduced so much that the stratospheric sulfur release experiment would not take place," he wrote. "Currently, this looks like a pious wish."

- *Creating clouds artificially to reflect sunlight*.

Shown in the picture above is the Philips-Salter device.

- *Feeding oceanic algae*.





These experiments seem to have failed.

- *Cutting emissions of* CO_2 *to zero, and the thermal inertia effect.*

The thermal inertia effect means that CO_2 remaining unabsorbed in the atmosphere would continue to feed global warming for over 100 years under the scenario that human CO_2 emissions were stopped completely.

A technology that would enable an electric economy is the *polymer solar cell*, a type of flexible solar cell made with polymers, large molecules with repeating structural units, that produce electricity from sunlight by the photovoltaic effect. Polymer solar cells include organic solar cells (also called "plastic solar cells"). They are one type of thin film solar cell, others include the more stable amorphous silicon solar cell. Polymer solar cell technology is relatively new and is being actively researched by universities, national laboratories, and companies around the world.

Polymer solar cells suffer from a lack of enough efficiency for large scale applications and stability problems but their promise of extremely cheap production and eventually high efficiency values has led them to be one of the most popular fields in solar cell research. It is worth mentioning that state-of-the-art devices produced in academic labs – with the record held by Yang Yang's group in UCLA – have reached certified efficiencies above 8% while devices produced which have remained unpublished – probably to maintain secrecy for industrial applications – are known to have already gone above 10%.