

## **Unscrambling the egg: self-motivated organisms and the work of the biosphere**

by Peter Donovan, December 2009

[soilcarboncoalition.org/unscrambling-the-egg](http://soilcarboncoalition.org/unscrambling-the-egg)

It is often said that you can't unscramble an egg. An egg has a wholeness or integrity, a poised arrangement of membranes and layers. You cannot reverse the breaking, mixing, and cooking, even with the most advanced technology and equipment.

But a hen can. Feed her a scrambled egg or two, and she can lay a new, whole egg. It may not be instant, but expensive technology is not required. If the egg is fertile, it can become a new hen, who can unscramble more eggs, and so on.

It's important to remember the relationship here, and who has the power. The hen wants to eat it, and produce a new egg, for reasons that are hers, not ours. Like all the biosphere's organisms, she is self-motivated. Trying to force her may cause problems for both her and us. If we want the egg unscrambled, we invite her.

We've got a scrambled egg situation on a global scale: biodiversity loss, extensive land degradation, water shortages, acidifying oceans, and too much heat-trapping carbon in the atmosphere. But we've framed it in such a way that the hen isn't even in the picture.

Of all these large problems, it was perhaps inevitable that carbon in the atmosphere took center stage in the 1970s and after. The data about rising carbon dioxide in the atmosphere were clear. Physical sciences were dominant in climate questions, and the scope and variability of the biological carbon cycle were only beginning to emerge.<sup>1</sup>

That transparent carbon dioxide gas absorbed and emitted long-wave radiation, thus trapping heat, had been discovered in the 1800s. By the 1960s it was clear that atmospheric carbon dioxide was increasing steadily. But it took another generation, as well as a massive and varied accumulation of evidence, before most scientists and the public began to accept the possibility that climate could change as a result of human activities, and that fossil fuel burning was the main driver.

Of course, many do not accept this formulation. It's not just the evidence. Beliefs vary about the power of human technology in relation to the planet. Those who grew up with stories about the global reach of pesticides and nuclear radiation, or in the age of Google where technology seems to change everything, have an easier time accepting the idea of human-caused global warming. Belief plays a critical role in how we frame problems and their solutions, as well as how we evaluate evidence.

Since fossil fuel burning was the cause, the solution to the atmospheric problem was

self-evident: stop or reduce it. The problem, climate change, was instantly defined in terms of its solution, which was to reduce emissions. This placed the power for change with technology—whether new energy systems, efficiency, or limits on old technology.

Reducing fossil fuel use would be a fine thing for all sorts of reasons, but IPCC scenarios from 2007 indicate that even complete elimination of fossil fuel burning gives only gradual and modest reduction of atmospheric carbon dioxide. It would immediately dispense with a significant aerosol cooling effect.<sup>2</sup>

But problem and solution are still joined at the hip. Emissions reductions are social and economic issues too, and resistance easily turns into denial of human-caused climate change. This long-running and bitter controversy may pretend to be about science or evidence, but it's mainly about beliefs and the values that surround them. The conflict has tended to harden the definition of the problem as mainly an atmospheric pollution or technology issue on the one hand, or as a matter of changes in solar output on the other. In neither case do we have much leverage, and remain powerless to unscramble the egg or even turn down the heat significantly.

Emissions trading or cap and trade systems, even when extended to biological carbon absorption by trees or soil, still leaves technology and its limits in the driver's seat. By definition, offsets—payments for avoided or withheld emissions—cannot exceed emissions. Yet in order to reduce atmospheric carbon, more carbon must be subtracted from the air than added. We can't do that with offsets.

With the problem increasingly institutionalized as one of atmospheric pollution, and with the power for change assigned to technology or to limits on it, and with steady and committed resistance to this framing, we aren't in a position to solve it. Clean energy systems and emissions reductions, while necessary and beneficial, are not enough. We are trying to extend technology with atmospheric dialysis, air capture of carbon with lye, and even with fantasies of reversing the basic chemistry and thermodynamics of coal combustion. We still cannot seem to imagine or recognize the hen that could unscramble the planetary egg.

But she may be quietly edging into the picture.

The biosphere is the sum of all the living and the dead. It doesn't just sit there looking pretty, wild, or vulnerable. It does work, a lot of it. In addition to the enormous deposits of fossil fuels whose oxidation currently powers our civilization, the biosphere's resume includes the calcium carbonate rocks that cover a tenth of the earth's surface, banded iron ore formations that supply our steel, much of ocean chemistry, soils that feed the world, peat formations, and the composition of the atmosphere. Current responsibilities include feeding everybody, capturing and holding soil moisture for land dwellers, and all the rest of what are called ecosystem services.

The pattern and process of this work is the carbon cycle. Carbon is life and food, and cycles from atmosphere to plants and back. The dead can become soil. On land alone, the biosphere moves 10 times the carbon, and does 10 times the work, of all fossil fuel burning.<sup>3</sup> The hub of the terrestrial carbon cycle, containing more carbon than atmosphere and forests combined, is soil organic matter.

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For millennia, humans have unwittingly let huge quantities of this soil carbon—the decayed residue of living tissue—oxidize into atmospheric carbon dioxide through fire, tillage, drainage, and insufficient and excessive rest periods from grazing. More recently, life-killing chemicals and mechanical tillage have accelerated the loss.

Bare, uncovered soil indicates not only leakage of soil carbon into the atmosphere, but the absence of life that can replenish it. Since before the dawn of history, human habits and activities have contributed to the oxidation side of the biosphere's carbon cycle and subtracted from the photosynthesis side.<sup>4</sup> Over the vast areas of bare soils between the plants on much of our grasslands and croplands, the biosphere and its carbon cycle—the solar-powered engine of all ecosystem services—is barely idling.

These are still unfamiliar concepts and phenomena. Compared to our noisy and concentrated energy technology, carbon cycling is quiet, gradual, spread out over vast areas, and usually invisible. It doesn't have any corporate or institutional sponsors. Yet on land alone, even with many cylinders out of play, it does 10 times the work.

From the edges comes a motley countertrend, which some are calling the second agricultural revolution. Innovative, independent, and practical farmers and graziers of every stripe, and a few scientists, on every continent, are figuring out how to increase productivity while reducing inputs, and enhancing their lives and communities. Though there is a huge diversity of practices, one common denominator is to let solar-powered plants, animals, and microbes do more and more of the work, and to keep soils covered with live or dead plants throughout the year.

On thousands of acres, some of these land managers have also measured spectacular reversals and more of soil carbon loss, turning atmospheric carbon into water-holding, fertility-enhancing soil organic matter rapidly and cheaply. Robust documentation is scarce, but farmers and graziers on several continents have doubled soil carbon in a decade, as a kind of byproduct of their quest for better ways to manage land. A project in the California delta has built 2 feet of peat soil in 10 years, accruing an estimated 10 tons of carbon per hectare per year.<sup>5</sup>

These reversals challenge widely held beliefs that biological processes are slow and weak, and that only technology (or geologic cataclysms) can change landscapes rapidly. But they also suggest a hypothesis. What if, by managing the soil surface so as to reduce losses of soil carbon and increase the gains, we could gain enough leverage over the carbon cycle to unscramble the egg?

A 3% increase in total soil carbon would soak up carbon equivalent to an atmospheric reduction in carbon dioxide from 390 to 350 parts per million, and would give huge progress against land degradation, biodiversity loss, and water scarcity as well.<sup>6</sup>

Testing the hypothesis would not require legislation or international agreements. It can be done at almost any scale.

The biosphere's carbon cycle operates through self-motivated, self-reproducing organisms, most of them microscopic or vegetative. It cannot be forced. It's process, not just events, and complex relationships, not just mechanical practices. How do we work with the biosphere's carbon cycle, and let it do its best work? What kind of person, what kind of behaviors are likely to succeed at this, in varied situations and environments? We don't know. Policy, regulation, or best practices as determined by research aren't good strategies for exploring the possibilities.

What we need is to test a large variety of strategies and behaviors. Because strategies need to be sustainable and pursued with commitment, the creativity and choice is best left to the land managers and farmers who will try them.

They are also most likely to be motivated by the outstanding local benefits of increased soil organic matter, which holds many times its weight in water, moderating both floods, droughts, and enhancing groundwater and streamflow. Soil organic matter is the matrix for biodiversity and self-sufficient agricultural productivity. The more you have, the more you can produce, not just plants and soil moisture but soil organic matter itself. Poor people can engage in growing soil carbon, using powerful tools many already have, such as herds of livestock which can be used to revitalize degraded grasslands and shrublands.

To explore these possibilities, and learn from people's efforts, we need to measure changes in soil carbon over time. Soil carbon is a key indicator of the biosphere's work, of the surplus of photosynthesis over oxidation. Laboratory testing for soil carbon is highly accurate, and not that expensive. Simple sampling tools such as probes and shovels can do the job.

If you are interested in helping to test the hypothesis, or to enlist the biosphere's carbon cycle in unscrambling the egg, the Soil Carbon Challenge ([soilcarboncoalition.org/challenge](http://soilcarboncoalition.org/challenge)) is an international and localized prize competition to see how fast land managers can turn atmospheric carbon into water-holding, fertility-enhancing soil organic matter. We're looking for entries and supporters.

## Notes

<sup>1</sup>For an excellent account of the discoveries and shifts in belief that enabled the discovery of global warming, see Spencer Weart's *The Discovery of Global Warming* (Harvard University Press, 2003). An updated version is online at [aip.org/history/climate](http://aip.org/history/climate)

<sup>2</sup>See section 10.3 of the FAQ to the Intergovernmental Panel on Climate Change 2007 Fourth Assessment: "Complete elimination of CO<sub>2</sub> emissions is estimated to lead to a slow decrease of atmospheric CO<sub>2</sub> of about 40 ppm over the 21st century." [www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-faqs.pdf](http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-faqs.pdf) For the estimated magnitude of the aerosol cooling effect, see [ipcc-wg1.ucar.edu/wg1/FAQ/wg1\\_faq-2.1.html](http://ipcc-wg1.ucar.edu/wg1/FAQ/wg1_faq-2.1.html)

<sup>3</sup>Rattan Lal, Sequestration of atmospheric CO<sub>2</sub> in global carbon pools, *Energy and Environmental Science* 1:86–100 (2008), Figure 1.

<sup>4</sup>William Albrecht, who was soils professor at the University of Missouri during the 1920s and 1930s, wrote a succinct description of the loss of soil organic matter the American Midwest since the 1800s: "But with the removal of water through furrows, ditches, and tiles, and the aeration of the soil by cultivation, what the pioneers did in effect was to fan the former simmering fires of acidification and preservation into a blaze of bacterial oxidation and more complete combustion. The combustion of the accumulated organic matter began to take place at a rate far greater than its annual accumulation. Along with the increased rate of destruction of the supply accumulated from the past, the removal of crops lessened the chance for annual additions. The age-old process was reversed and the supply of organic matter in the soil began to decrease instead of accumulating. . . Organic matter may well be considered as fuel for bacterial fires in the soil . . ." In *Soils and Men: Yearbook of Agriculture*, 1938, pp. 347–360. Also available from <http://www.soilandhealth.org/01aglibrary/010120albrecht.usdayrbk/lsom.html>

<sup>5</sup>Roger Fujii and Robin Miller, personal communication, June 2008; see Miller's paper on this experiment at [repositories.cdlib.org/jmie/sfews/vol6/iss3/art1/](http://repositories.cdlib.org/jmie/sfews/vol6/iss3/art1/)

<sup>6</sup>Estimates of carbon fluxes and pools are from Rattan Lal, Sequestration of atmospheric CO<sub>2</sub> in global carbon pools, *Energy and Environmental Science* 1:86–100 (2008).