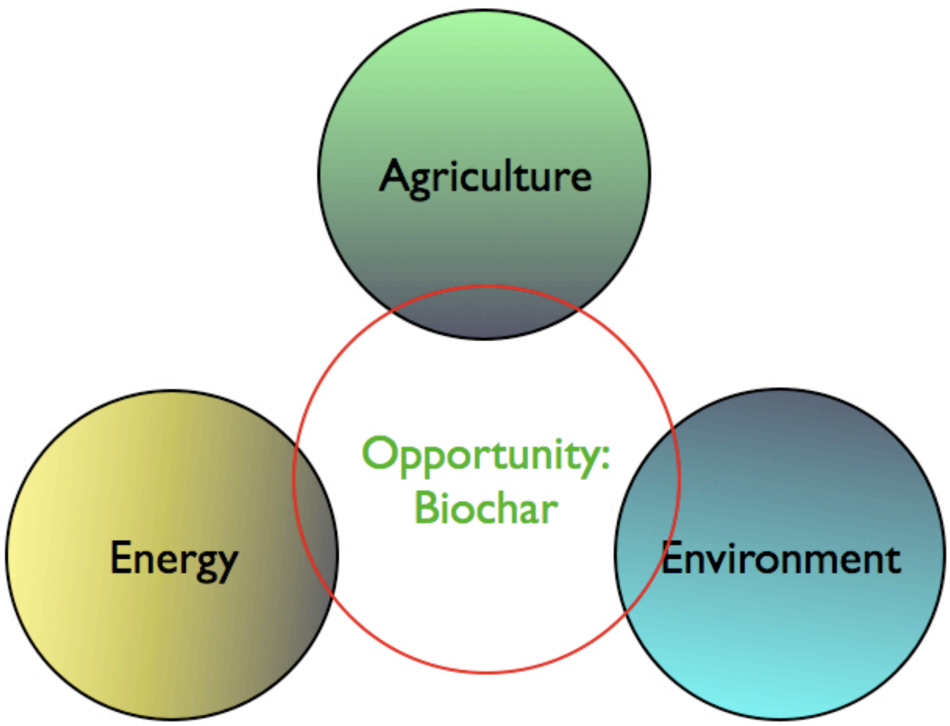
Biochar

The intersection of Agriculture, Energy & the Environment
Establishing a Long Carbon Cycle
An approach greater than the sum of its parts



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Introduction:

If the maximum "safe" level of CO_2 in the atmosphere is 350 parts per million, but today's level is ALREADY 385 ppm, is it "good enough" to simply reduce the rate at which we are adding CO_2 to the atmosphere? Simply put, is any policy option limited to a 'reduction in the rate of increase' merely a re-arranging of the deck chairs on the Titanic?

Or, as seems logical, must we reverse direction and start REMOVING CO_2 from the atmosphere as rapidly as possible? Can we reduce CO_2 in the atmosphere by at least 10% fast enough to prevent serious global climate disruption? Attempting anything less would seem to be akin to voting for a disastrous future.

In 2007, we were already at at CO_2 level of 383 ppm. So we have known of this overshoot for at least two years. We have, however, yet to hear any serious talk of changing direction. Nor is there any action to remove CO_2 from the atmosphere on a global scale in order to attempt to preserve a semblance of life as we have know it. History shows that overshooting limits and carrying capacities inevitably has dire results: die offs and collapses. Is this what we want for our future?

If not, we had best learn how to "price" CO_2 more completely and accurately so that the market can function properly with valid pricing information. Currently, we seem to be pricing our CO_2 habit with marked cards and crooked dice in order to force the market to give us answers we like: cheap energy. In the end, if we cook the books, the results will surely cook us.

Is biochar, the subject of this note, one way to reverse direction, make the soils healthier and more productive, as well as make a profit with increased crop yields? A profit driven approach to removing CO_2 from the atmosphere seems the most likely to succeed. How would we engineer this on a global scale to achieve the results we desire in the required time frame?

See Elizabeth Kolber's essay on James Hansen in the June 29th issue of The New Yorker magazine.

And Bill McKibben's article in the Dec. 28th, 2007 Washington Post:
Remember This: 350 Parts Per Million

Important resource:

Welcome to the International Biochar Initiative.

IBI is a registered non-profit organization supporting researchers, commercial entities, policy makers, development agents, farmers and gardeners, and others committed to supporting sustainable biochar production and utilization systems that remove carbon from the atmosphere and enhance the earth's soils. It advocates biochar as a strategy to:

- improve the Earth's soils;

- help mitigate the anthropogenic greenhouse effect by reducing greenhouse gas emissions and sequestering atmospheric carbon in a stable soil carbon pool; and improve water quality by retaining agrochemicals.

The IBI also promotes:

- sustainable co-production of clean energy and other bio-based products as part of the biochar process;

- efficient biomass utilization in developing country agriculture; and

- cost-effective utilization of urban, agricultural and forest co products.

From the IBI web site:

Biochar is a fine-grained charcoal high in organic carbon and largely resistant to decomposition. It is produced from pyrolysis of plant and waste feedstocks. As a soil amendment, biochar creates a recalcitrant soil carbon pool that is carbon-negative, serving as a net withdrawal of atmospheric carbon dioxide stored in highly recalcitrant soil carbon stocks. The enhanced nutrient retention capacity of biochar-amended soil not only reduces the total fertilizer requirements but also the climate and environmental impact of croplands. Char-amended soils have shown 50 - 80 percent reductions in nitrous oxide emissions and reduced runoff of phosphorus into surface waters and leaching of nitrogen into groundwater. As a soil amendment, biochar significantly increases the efficiency of and reduces the need for traditional chemical fertilizers, while greatly enhancing crop yields. Renewable oils and gases co-produced in the pyrolysis process can be used as fuel or fuel feedstocks. Biochar thus offers promise for its soil productivity and climate benefits.

How is Biochar carbon-negative?

The overall bio-char process is *carbon negative.* A *carbon neutral* process is one that does not add to the climate change problem, but does not actually reverse the problem either. An example of a carbon neutral activity is burning biomass for energy in place of fossil fuel. The bio-char process, by contrast, produces a combination of *both* bio-energy and carbon-sequestering fertilizer from agricultural waste, which results in a net reduction of carbon dioxide (CO_2) from the atmosphere. As a soil amendment, char can sequester or store the carbon in the soil for hundreds and even thousands of years in the stable char matrix. Equally important, the char improves soil fertility, thereby stimulating plant growth, which then consumes more CO_2 from the atmosphere. The bio-energy produced as part of the process can be turned into electricity, process heat, ethanol, methanol, or soon, an ultra-clean liquid diesel fuel. The net amount of CO_2 in the atmosphere from both these products is thus reduced, making the bio-char process carbon negative and also regenerating soil fertility in the process.

Terra Preta Soils

The biochar process is akin to a process utilized thousands of years ago in the Amazon Basin, where islands of rich, fertile soils called *Terra Preta* (“dark earth”) soils were created through a process similar to pyrolysis. The high fertility and carbon content of these soils – retained thousands of years later in the absence of additional inputs – is the subject of much research and agricultural interest, and underlies the formation of the International Biochar Initiative. Because the biochar is relatively inert, most of it remains in the soils for orders of magnitude longer than any other organic amendments. This means that biochar might be one of the only tools available in the near future that can actually remove carbon from the atmosphere in a virtually permanent form.

See: http://www.biochar-international.org/aboutbiochar/informationaboutbiochar.html

Note: There is a "Biochar White Paper" at the above site as well.

Carbon: Profitable to Use, Dangerous to Lose

Carbon,in the form of Biochar, generates profits by adding real value to soil productivity; it gives off profitable thermal energy in its production; and creates profitable benefits by improving the quality of the atmosphere, water and its use, while potentially ending the need for slash and burn agriculture.

On the other hand, 'losing' carbon as CO2 back into the atmosphere is a real danger as a driver of global climate disruption. 'Losing' carbon by pumping it down into deep wells, where it turns water into carbolic acid, creates a potentially extremely dangerous route to massive CO2 releases in the future.

Biochar is: Low tech, cost effective, an easily distributed solution that is known to work, and has a proven safety record thousands of years long. Biochar is silver buck shot, not a silver bullet. CO2 sequestration in deep wells, on the other hand, has none of the above established attributes.

Should we bet the future of Spaceship Earth on a sure thing or a crap shoot? Isn't it about time we put Buckminster Fuller's "comprehensive, anticipatory, design science" into practice?

Presentations on Biochar & Terra Preta

1. **National Geographic**
Superdirt Made Lost Amazon Cities Possible?

John Roach -- for National Geographic News

November 19, 2008

Scroll down on the above page to watch nearly 6 minute *Video Clip From* Lost Cities of the Amazon *Documentary*

"Over the centuries, explorers traded tales of a lost civilization amid the dense Amazonian rainforest. Scientists dismissed the legends as exaggerations, believing that the rainforest could not sustain such a huge population -- until now. A new generation of explorers armed with 21st-century technology has uncovered remarkable evidence that could reinvent our understanding of the Amazon and the indigenous peoples who lived there. Using CGI and dramatic re-creations, National Geographic re-imagines the banks of the Amazon 500 years ago, teeming with inhabitants living in the *Lost Cities of the Amazon*." Source: http://shopngvideos.com/products/lost_cities_of_the_amazon

2. BBC
"The Secret of El Dorado"
49 minute program on Terra Preta & biochar.

3. **The Promise of Biochar**: An excellent 12 minute video introduction to biochar.

"VenEarth is a major supporter of the International Biochar Initiative. This video was produced by IBI for the Poznan round of climate discussions, during which biochar was placed on the agenda for Copenhagen."

The video features Johannes Lehmann, Associate Professor of soil biogeochemistry and soil fertility management at Cornell University. As per the profile below, Prof. Lehmann is a recognized expert in this subject area.

4. On the same site, find the slides with voice-over: **Soil Carbon, Science, Policy and Politics**, a 15 minute presentation by John Moussouris.

"**John Moussouris**

Before founding VenEarth, Mr. Moussouris was founding CEO and Chairman of MicroUnity Systems Engineering, Inc., a developer of broadband microprocessor technologies licensed widely across the computing industry. Earlier he cofounded MIPS Computer Systems, where he led development of processors used in Sony Playstations, Cisco routers, and other innovative products. He taught at Stanford University and was a research staff member at IBM's Watson Lab and at the MIT Laboratory for Computer Science. He received an A.B. in physics from Harvard and a D.Phil in mathematical physics with Sir Roger Penrose as a Rhodes Scholar at Oxford. His interest in climate mitigation dates back to a low-pollution combustion engine company he cofounded in college.

Enthusiasm for sustainable agriculture took root during summers on his grandparents' traditional organic farm on the Greek island of Cephalonia."

5. **Congressional Research Service**

Biochar: Examination of an Emerging Concept to Mitigate Climate Change.

Author: Kelsi S. Bracmort
Analyst in Agricultural Conservation and Natural Resources Policy

February 03, 2009 / 11 pages

6. **CSIRO Land and Water Science Report 05/09**

Biochar, climate change and soil:
A review to guide future research

65 pages

First Scholarly book on Biochar:

Biochar for Environmental Management: Science and Technology (Hardcover).

This is also listed on the IBI web site.
"**Editorial Reviews** [From the Amazon listing.]

Product Description
The unique properties of black carbon-rich soils have only recently been recognized and international efforts have significantly increased to utilize this knowledge to improve agriculture and the environment in several ways.

Biomass-derived black carbon, charcoal or "biochar", as it is nowadays called, can be used as a soil amendment to improve nutrient retention and availability and therefore increase crop yields. Such a use of biochar is a significant advance over conventional organic matter management, as the biochar is more stable in soil and is better able to retain nutrients. In combination with sustainable biomass production, such a biochar sequestration can be carbon negative and therefore be used to actively remove carbon dioxide from the atmosphere, with obvious significance for mitigation of climate change. Biochar production can also be combined with bioenergy production through the use of the gases that are given off in the pyrolysis process. This book is the first to synthesize the expanding research literature on this topic. This is all the more important at this juncture in the development of a biochar technology, as it requires an interdisciplinary approach involving engineering, environmental sciences, agricultural sciences, economics, and policy. The book provides a comprehensive overview of current knowledge of the science and technology of biochar.

About the Author
Johannes Lehmann is Associate Professor of soil biogeochemistry and soil fertility management at Cornell University, USA, co-founder and Chair of the Board of the International Biochar Initiative, and member of the journal editorial boards of Nutrient Cycling in Agroecosystems and Plant and Soil. Stephen Joseph is a visiting professor at the School of Materials Science and Engineering at the University of New South Wales, Australia, and Vice Chairman of the International Biochar Initiative."

Biomass Refinery Product Mix:

A dry ton of biomass can be refined into a range of products:

thermal energy
electricity
biochar
syngas
synoil

The technology used, as well as variations in the processing temperatures, oxygen levels, and processing time influence the proportions of the mix. Biochar production can range from 20% to 50% depending on the variables of production.

The syngas can be converted to Methanol, as per the work of Biochar Engineering of Colorado -- as referenced below.

Wikipedia

The Biochar Wikipedia page is a treasure trove of information. The links at the bottom of the page are very useful too.

http://en.wikipedia.org/wiki/Biochar

and: http://www.css.cornell.edu/faculty/lehmann/index.html

and: http://www.cruciblecarbon.com/

Crucible Carbon is an Australian company

The above links imply that biochar can function as 'fertilizer', or soil amendment, that also allows an entry into the energy business as well.

Chicken litter biochar in Virginia, see the above referenced 12 minute video, increased crop yields by 300% and farmers were willing to pay $200 - $250 per ton delivered to their farms. The thermal energy produced was enough to heat the chicken barns. Note: other sources suggest prices as high as $500 per ton.

Further, low tech biochar production can be used as a process to actually significantly reduce the amount of CO_2 in the atmosphere by sequestering the carbon in the soil. The carbon is reported to stay sequestered for up to 5,000 years, a truly long carbon cycle. This makes the biochar cycle strongly carbon NEGATIVE.

Is it enough to embrace technologies that do not offer all three plays?

So why are we not supporting an international campaign for biochar? What is the climate benefit per dollar of biochar investment vs a dollar invested in any form of ethanol?

Good articles:

1. **The New York Times**:

 http://www.nytimes.com/cwire/2009/05/01/01climatewire-biochar-one-way-to-deal-with-more-fire-prone-12208.html

2: **The Financial Times** on biochar.

http://www.ft.com/cms/s/2/67843ec0-020b-11de-8199-000077b07658.html

If we feed the plain biochar to cows, it is said it helps to reduce flatulence, smell of excrement, and comes out of the cow thoroughly pre-mixed with the manure. Thus, when the manure is spread on the field, the biochar is delivered with a load of nutrients -- creating value greater than the sum of the parts.

[Searching “cow biochar” on Google returns many interesting results.]

3. **The Land** -- Australia

http://theland.farmonline.com.au/news/nationalrural/agribusiness-and-general/general/burn-bury-and-bargain-with-it-biochar-ticks-the-green-boxes/1527966.aspx?src=enews

4. **Biochar: The Key to Carbon-Negative Biofuels**
by Thomas R. Blakeslee, Clearlight Foundation
April 22, 2009

5. **Nature** article: Putting the carbon back Black is the new green:

[Thanks to Erich J. Knight for this pointer.]

6. Pushker Kharecha and Jim Hansen write:

We never said biochar is a miracle cure

7. **National Geographic**
Our Good Earth: The future rests on the soil beneath our feet.
By Charles C. Mann. Sept. 2008

8. Environmental and Energy Study Institute
Can Biochar Answer Both Climate and Energy Challenges?

Web Resources:

Biochar Fund
Fighting Hunger, Energy Poverty, Deforestation, & Climate Change - Simultaneously

http://terrapreta.bioenergylists.org/company
Information on the intentional use of Biochar (charcoal) to improve soils.

http://www.carbon-negative.us/gateway.htm

http://csp.unl.edu/Public/index.html
University of Nebraska Carbon Sequestration Program
Sustaining Earth and its People: Translating Science into Practice

William I Woods, Professor, Department of Geography at the University of Kansas.

Susanna Hecht, Ph.D. in Geography, University of California, Berkeley, Professor of Urban Planning

Michael J. Heckenberger, University of Florida, Dept. of Anthropology.

Earth Science Forum thread on these soils contains further links.

Terra Preta Discussion , central data base, and Mail list at REPP-CREST.

[Thanks to Erich J. Knight for the above two links and many others.]

Biochar technology developments in the US:

1. Biochar Engineering, Golden, CO 80403

From their web page:

“The biochar process is carbon negative: it removes net carbon from the atmosphere. When a green plant grows, it takes CO2 out of the air to build biomass. All of the carbon in the plant came from CO2 taken out of the air, and returns to the air when the plant dies and decomposes. When the biomass is instead pyrolyzed—heated in the absence of oxygen—it produces charcoal, which is called biochar when it is buried in the ground. Over 40% of the total carbon from the waste biomass is retained in biochar and sequestered in the soil for thousands of years, effectively removing that carbon from the atmosphere. The carbon in one tonne of biochar is equivalent to 3 to 3.5 tonnes of CO2.

Biochar is not only a carbon sink, it increases soil fertility—increasing cat-ion exchange and water retention capacity in soils, while reducing nutrient leaching and providing a "coral reef" for soil microorganisms—thereby significantly increasing productivity and crop yield, often by 80%-220%, depending on the original quality of the soil. Initial studies also suggest that biochar reduces nitrous oxide and methane emissions from soils, two greenhouse gases that are far more potent than carbon dioxide.”

From: http://www.biocharengineering.com/biochar/index.html

Note that in 2010, they plan to have a system that converts 1 ton of dry biomass into:

1. 500 lbs of biochar ~ 5.5 million BTUs

2. 80 gallons of Methanol = 4.8 million BTUs

3. Thermal energy ~ 5.7 million BTUs

See: http://www.biocharengineering.com/solutions/index.html

Methanol is an excellent medium for the storage and transportation of the solar energy initially captured by biomass. Additionally, Methanol is a precursor to DME, a diesel fuel, as well as ethylene and propylene. These in turn are precursors to a world of plastic products. This ability to produce Methanol from biomass is a very interesting precursor to developing an option for a Methanol Economy.

2. Best Energy, Madison, WI

"What is Slow Pyrolysis?
pyrolysis is a thermochemical decomposition of organic material at elevated temperatures in the absence of oxygen. The feed material is dried and fed into a stirred, heated kiln. As the material passes through the kiln, a combustible synthesis gas (syngas) is evolved and is continuously removed from the kiln. Approximately 35% by weight of the dry feed material is converted to a high-carbon char material that is collected on the discharge of the kiln."

Biomass Feedstock for Slow Pyrolysis		
▸ Poultry litter ▸ Dairy manure ▸ Greenwaste ▸ Nut shells	▸ Paper sludge ▸ Straw ▸ Wood waste ▸ Woody weeds	▸ Distillers grain ▸ Cotton trash ▸ Rice hulls ▸ Switch grass

3. PyroGen Power Generation

Systems are available in 250 pound, 500 pound, 1,000 pound, 2,000 pound and 4,000 pound per hour sizes, producing from 20 Kilowatts to 2 Megawatts and more of power capacity, plus Pyro-Oil and Pyro-Char or Bio-Char."

4. University of Hawaii

"***Flash Carbonization™ process***
Research at the University of Hawaii (UH) has led to the discovery of a new Flash Carbonization™ process that quickly and efficiently produces biocarbon (i.e., charcoal) from biomass. This process involves the ignition of a flash fire at elevated pressure in a packed bed of biomass. Because of the elevated pressure, the fire quickly spreads through the bed, triggering the transformation of biomass to biocarbon. Fixed-carbon yields of up to 100% of the theoretical limit can be achieved in as little as 20 or 30

minutes. (By contrast, conventional charcoal-making technologies typically produce charcoal with carbon yields of much less than 80% of the theoretical limit and take from 8 hours to several days.) Feedstocks have included woods (e.g., leucaena, eucalyptus, and oak), agricultural byproducts (e.g., macadamia nutshells, corncobs, and pineapple chop), moist green wastes (e.g., wood sawdust and Christmas tree chips), various invasive species (e.g., strawberry guava), and synthetic materials (e.g., shredded automobile tires). Recently we began Flash Carbonization™ studies of raw sewage sludge produced in Honolulu's Ewa sewage sludge treatment plant. We were surprised by the ease with which air-dry sewage sludge can be converted into charcoal. We obtained charcoal yields of about 30% (dry basis) from the sewage sludge. The charcoal contained 45-51% ash and 40% fixed-carbon. Results of many of these tests are described in a series of technical, peer-reviewed, archival-journal papers that can be obtained by request to Prof. M.J. Antal."

Note that " Kingsford obtained a limited license in 2007". Kingsford Charcoal is owned by Clorox.

Biochar technology developments in the Asia:

Asia Pacific Biochar Conference 2009

Other Biochar projects:

IBI Member projects

Projects in nine countries.

Low Tech Biochar Cooking Pot:

Terra Preta Pot: Saving the planet, one pot at a time.