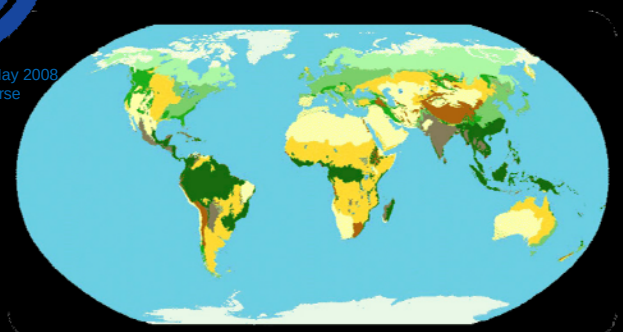
Soil Charcoal Amendments

to Maintain Soil Fertility and Fix Carbon

CSD 16 New York 9 May 2008
UNCCD Learning Course



http://www.ecoworld.com/maps/world_ecoregion.cfm

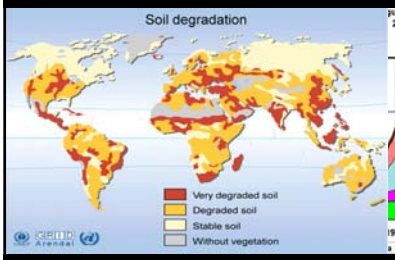
Scenarios for Major Eco-Regions

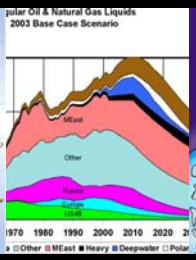
Christoph Steiner

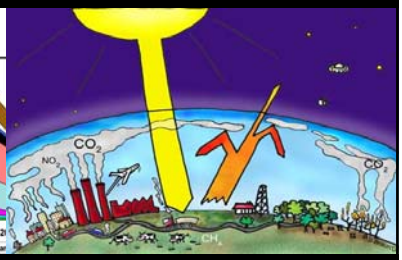
The University of Georgia
Biorefining and Carbon Cycling Program

biochar.org

Global problems







soil degradation peak oil "Hubbert's Peak" Climate change

in 2007

FAO's global **food price** index rose **40%**

to the highest level on record

World **fertilizer prices** surge **200%**

International Center for Soil Fertility and Agricultural Development, IFDC

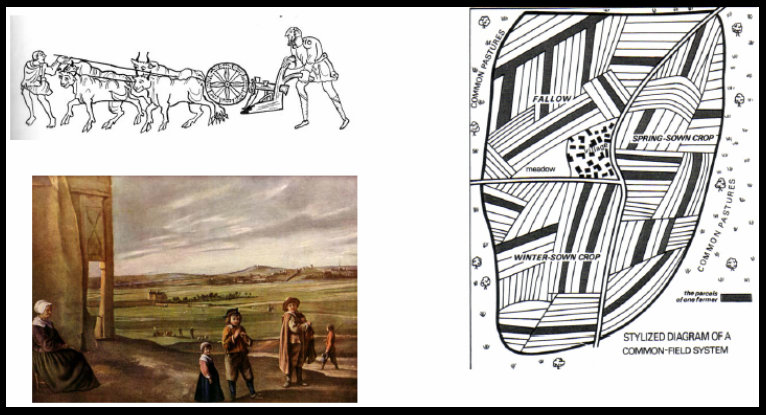
Dedicating land to biofuels increases carbon emissions

- **Corn-based ethanol doubles greenhouse gas emissions over 30 years**

Searchinger et al. 2008, Science

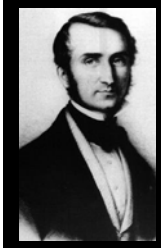
Soil degradation

Agriculture without mineral fertilizers – maintaining SOC



The soil C pool is 3.3 times the size of the atmospheric pool and 4.5 times the size of the biotic pool. Lal 2004, Science

Haber-Bosch mineral fertilizers



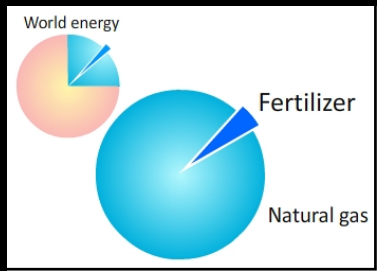
Justus von Liebig mineral nutrition of plants and
Haber Bosh process $N_2 + 3H_2 \rightarrow 2NH_3$

(http://www.liebig-museum.de)

Consumes 3.35% of world natural gas production = 0.75% of the world's energy supply

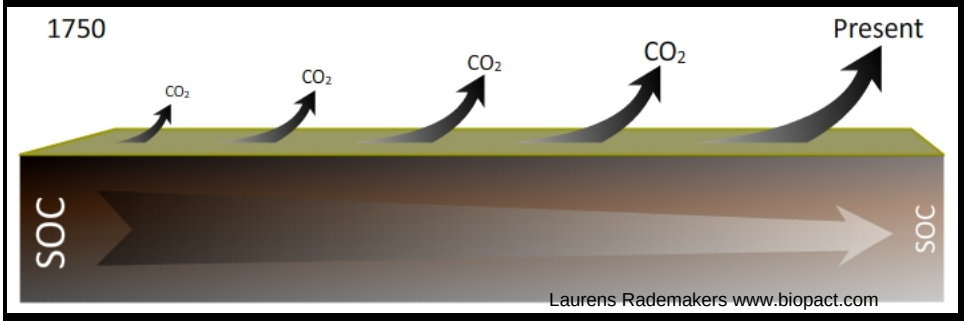
Boosted agricultural production and replenished nutrient stocks

but did not treat soil degradation caused by SOC loss



Soil degradation

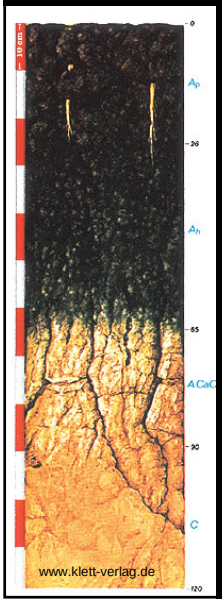
mineral fertilizers – further decline in SOC



Most agricultural soils have lost 60 to >75% (20 – 80 Mg ha^{-1}) of their original SOC (Lal, 2004, Science)

From 1750 the emissions form land use change contributed about 30% to global warming, from which more than half of it is estimated from depletion of SOC (*Lal*, 2003).

Example I Chernozem or mollisol



- Most agriculturally productive soils (Duchaufour, 1998)

(5. 12. 2004 world soil day, “Schwarzerde” = soil of the year 2005)

- Residues from vegetation fires, such as black carbon (BC) (Glaser *et al.*, 2000)
- BC constituting up to 45% of the SOM
- BC is several millennia in age (Schmidt *et al.*, 2002)

Example II Terra Preta

Cash crop farming

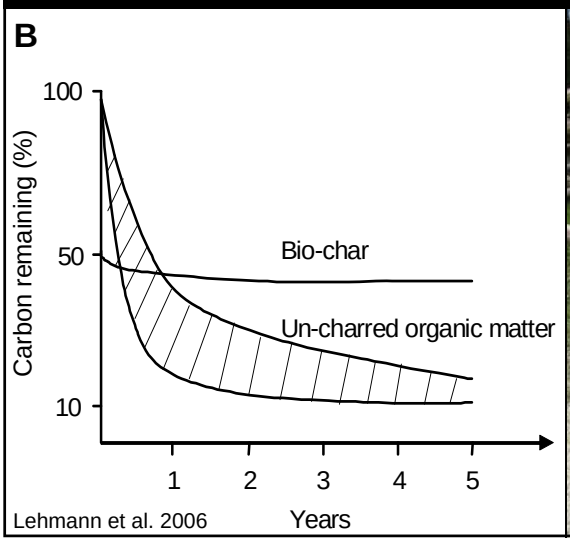
Irrigated horticulture

lawn production

Terra Preta fertility

Charcoal Carbon Sink

Long lasting carbon sequestration



Values of SOM

Nutrient content

Charcoal

Soil Quality

- maintenance and improvement of water infiltration
- Water holding capacity
- Structure stability
- Nutrient storage and supply
- Healthy soil biological activity

Carbon sink

- CDM
- Easy quantifiable

Biochar Research Terra Preta Nova

EMBRAPA research station Brazil

Research results

Increased yields with biochar
Lehmann and Rondon 2006, Steiner et al 2007, Plant and Soil

Increased retention of fertilized nitrogen = fertilization efficiency
Lehmann et al 2003, and Steiner et al 2008

Reduced GHG emissions (CH_4 and N_2O) form soil
Marco A. Rondón, Juan A. Ramirez, Johannes Lehmann, USDA Symposium on C sequestration. Baltimore, March 24, 2005

Reduced acidity
Topoliantz et al 2005, Steiner et al 2007

Increased mineral nutrition (mainly K)
Steiner et al 2007

Increased colonization rates my mycorrhizal fungi
Warnock et al. 2007, Plant and Soil

Biochar Production The simple way

Biochar Production in a cooking stove

Clean and efficient

Robert Flanagan, SAFFE

Biochar as byproduct from cooking

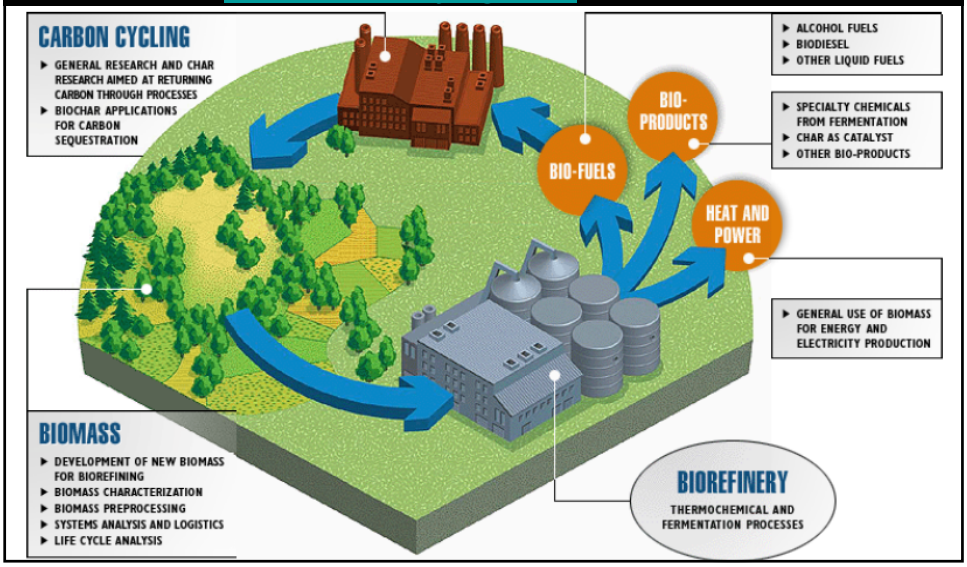
Corn cobs biomass/biochar

Robert Flanagan, SAFFE

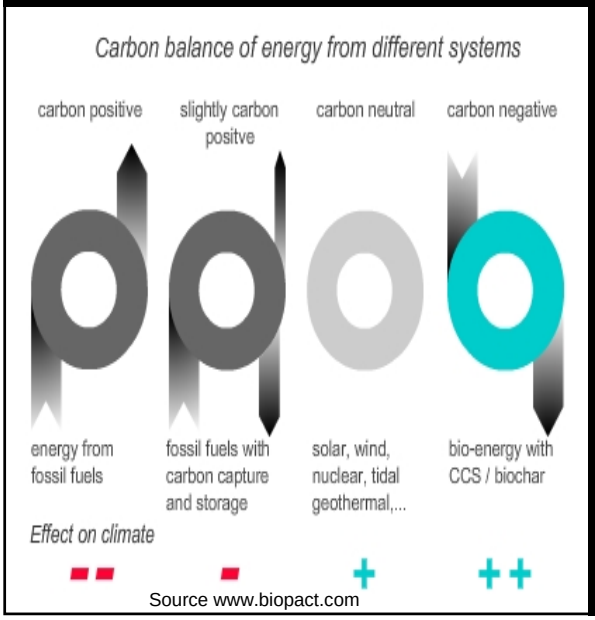
Biochar Production byproduct from pyrolysis

UGA Biorefining and Carbon Cycling Program

www.biorefinery.uga.edu



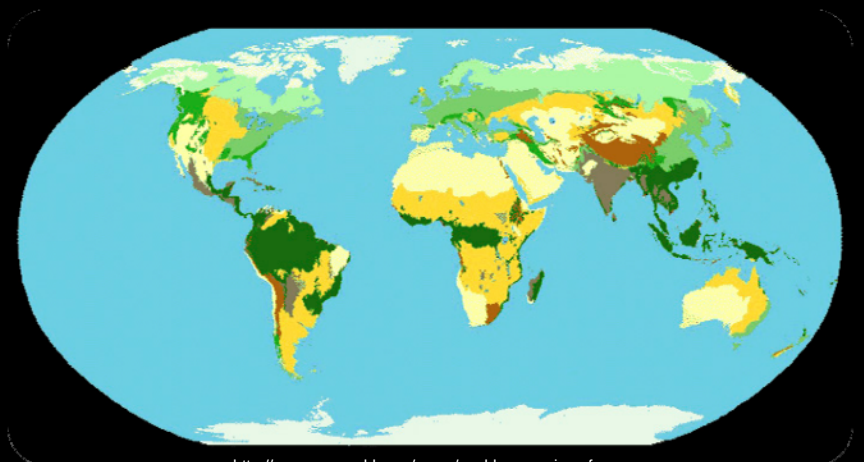
Biochar carbon negative energy



Source www.biopact.com

- Waste biomass can be used
- No competition with food production
- Carbon sequestration, restoring soil fertility and renewable energy production can be complementary

Resources global



http://www.ecoworld.com/maps/world_ecoregion.cfm

Resources global

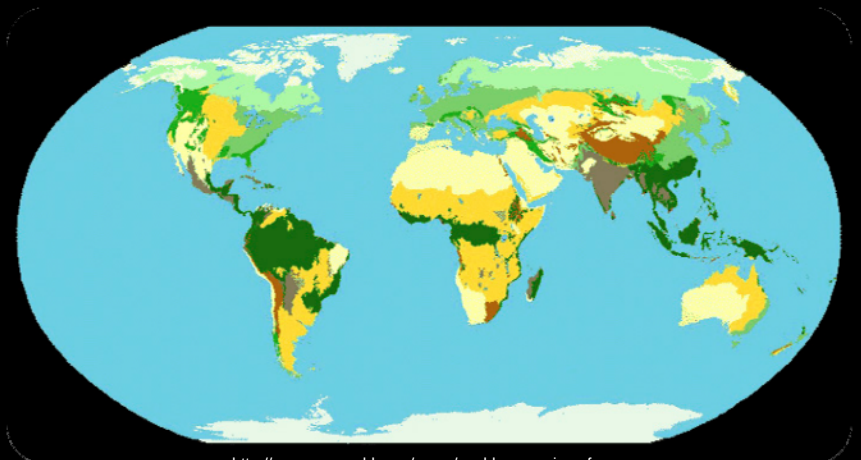
Global amount of crop residue produced is estimated at 2.8 Pg yr^{-1} for cereal crops and 3.8 Pg yr^{-1} for 27 food crops.
(without forestry residues) Lal 2005, Environment International

Globally 1.5 Pg yr^{-1} crop residues are wasted.
(7 most important crops) Kim and Dale 2004, Biomass and Bioenergy

Worldwide, the total carbon release from fire is 4 - 7 Pg yr^{-1}
(6 Pg from fossil fuel in 1990) Goudriaan 1995, *Global Carbon and Carbon Sequestration*

Burned agricultural wastes in the tropics 0.5 - 0.8 Pg yr^{-1}
Crutzen and Andreae 1990, *Science*

Tropical Forest humid



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Tropical Forest

slash and char as alternative to slash and burn

Tropical forest conversion contribute 25% of the global CO_2 emissions. Palm et al. 2004, Environment, Development and Sustainability

1.31 Pg yr^{-1} (billion tons) of biomass is cleared in all secondary forests (fallow vegetation) Fearnside 2000, Climatic Change

~50% of C remains as charcoal

~2% of C remains as charcoal

Tropical Forest

Sugar cane and palm oil plantations

Annual global sugar cane production is 0.33 Pg
- 44% Asia
- 27% Brazil

Average yield = 17 Mg ha^{-1} Kim and Dale 2004, Biomass and Bioenergy

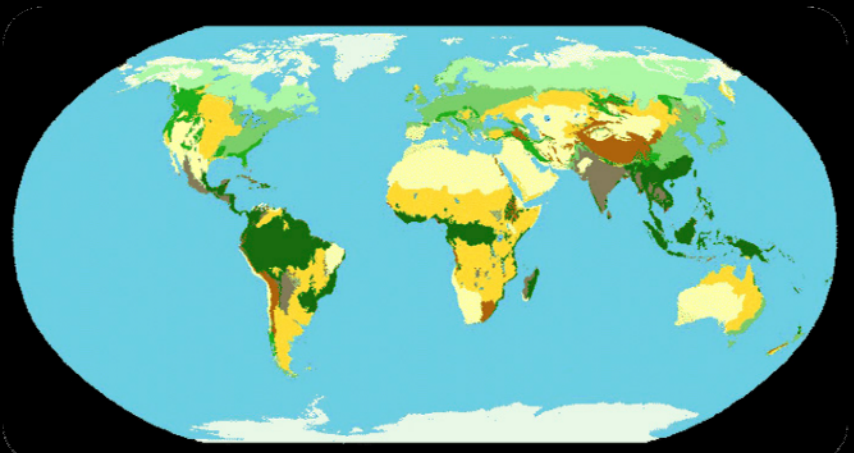
5 Million ha in Brazil producing 300 million tons (20% are harvested without burning)

Shredded stalks (bagasse) is burned to provide steam and electricity

Organic waste stream (vinasse) can be used as fertilizer or converted to methane

Cerri et al 2007, Sci. Agric.

Forest Savanna sub-humid



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Forest Savanna Namibia case study

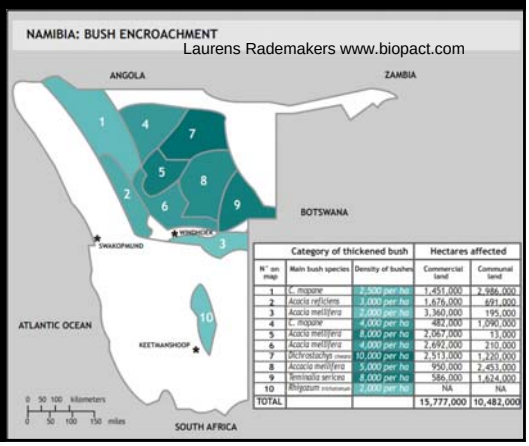
Drastically reduced productivity of agricultural land

10 – 12 million ha (12 – 14% of Namibia)

100 million tons of biomass available

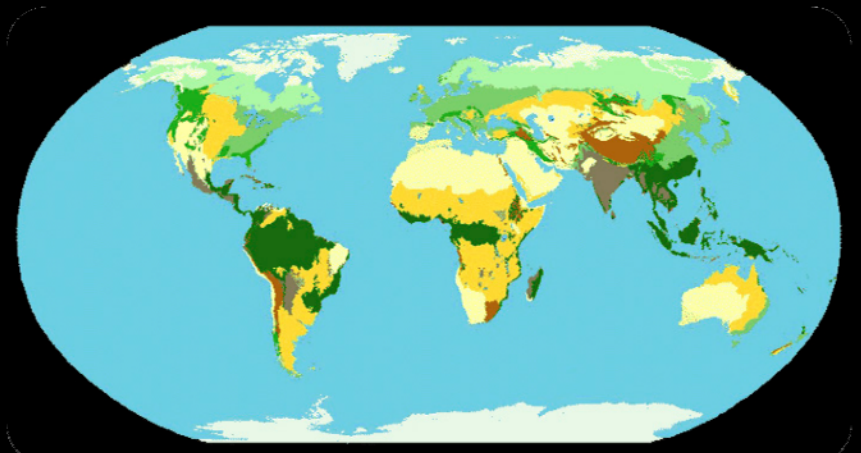
Harvest of 1 million ha yr^{-1} necessary

10 million tons of biomass per year = 40 TWh
(Electricity consumption of Namibia in 1999 12.6 TWh)



	Category of thickened bush		Hectares affected	
N° on map	Main bush species	Density of bushes	Commercial land	Communal land
1	*C. mopane*	2,500 per ha	1,451,000	2,986,000
2	*Acacia reficiens*	3,000 per ha	1,676,000	691,000
3	*Acacia mellifera*	2,000 per ha	3,360,000	195,000
4	*C. mopane*	4,000 per ha	482,000	1,090,000
5	*Acacia mellifera*	8,000 per ha	2,067,000	13,000
6	*Acacia mellifera*	4,000 per ha	2,692,000	210,000
7	*Dichrostachys*	10,000 per ha	2,513,000	1,220,000
8	*Acacia mellifera*	5,000 per ha	950,000	2,453,000
9	*Terminalia sericea*	8,000 per ha	586,000	1,624,000
10	*Rhigozum*	2,000 per ha	NA	NA
TOTAL			15,777,000	10,482,000

Drylands arid / semi-arid



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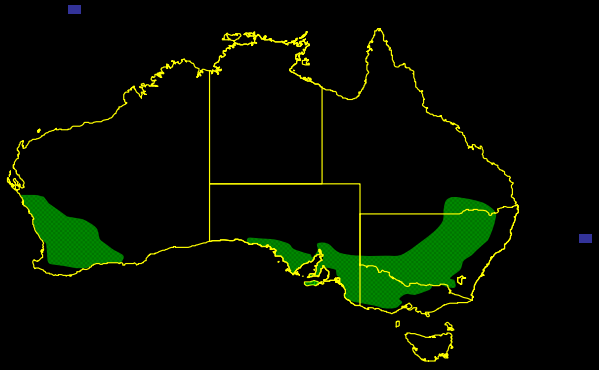
Drylands Australia case study 250 – 450 mm rainfall

Syd Shea (http://www.oilmallee.com.au/) and Paul Blackwell (http://www.agric.wa.gov.au/)

Salinization problem as response to 200 yrs of land clearing

30% of all farmland

2.4 million ha which could increase to > 15 million ha



Salinization threatens more than 400 species of Australian wildlife

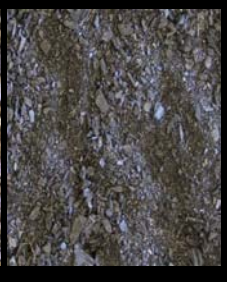
Drylands Australia case study

Alley cropping with Mallee Eucalyptus

From 1994 – 2001 7560 ha or 25 million trees planted (10 million ha needed)

20% - 40% of all agricultural land

Drylands Australia case study



Integrated production of

- Eucalyptus oil
- Energy
- Activated carbon
- And biochar carbon sink proposed

Presentation

http://www.biochar.org/