The Role and Potential of Soil Carbon Sequestration in Protecting Climate

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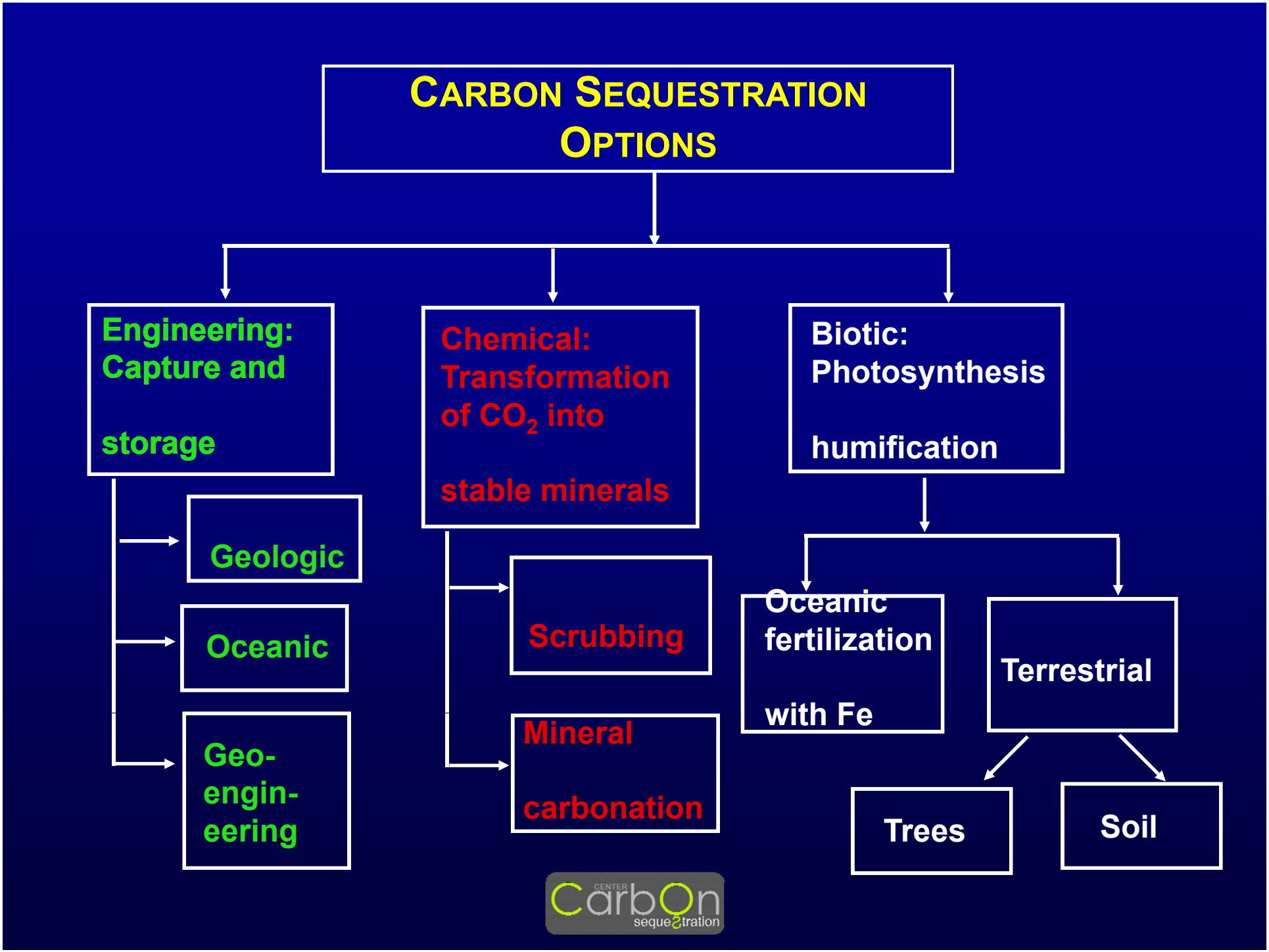
ATMOSPHERIC CHEMISTRY CO_2 CONCENTRATION

Year	PPMV
1750	280
1950	315
2008	380 (+2 ppm/y)

Greenhouse Effect and the Biosphere

For each 1°C increase in global temperature, the vegetational zones may move poleward by 200 to 300 km.


CARBON SEQUESTRATION OPTIONS
Engineering: Capture and storage
Chemical: Transformation of CO_2 into stable minerals
Biotic: Photosynthesis humification
Geologic
Oceanic
Geo-engin-eering
Scrubbing
Mineral carbonation
Oceanic fertilization with Fe
Terrestrial
Trees
Soil
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Biotic Pool = 600 Pg
SOC Pool = 1550 Pg
SIC Pool = 950 Pg
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sequestration

Soil Carbon and Atmospheric CO_2

1 Pg of soil C = 0.47 ppm

SOIL CARBON SEQUESTRATION

Transfer of atmospheric CO_2 into soil C pool as:

- **Soil organic carbon (SOC)**
- **Pedogenic carbonates**

GLOBAL SOIL ORGANIC CARBON POOL

- Magnitude to a 2-m depth = 2376 – 2456 Pg (2416 Pg)
- If SOC pool can be increased by 10% = 240 Pg
- 1 Pg of SOC pool = 0.47 ppm of CO_2
- Thus 10% increase = 112
- 10% Increase can reduce CO_2 concentration = 382 – 112 = 270 ppm

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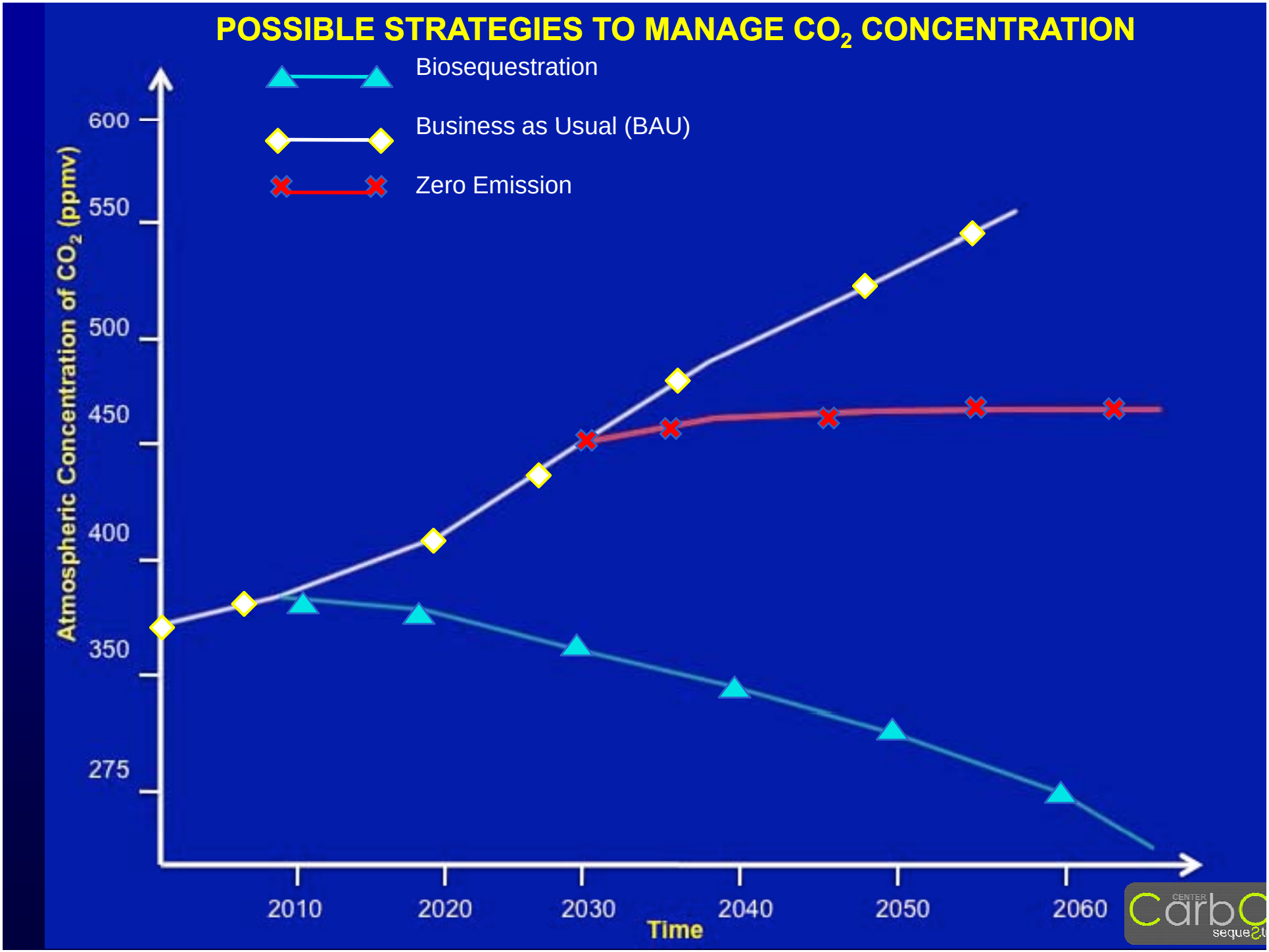
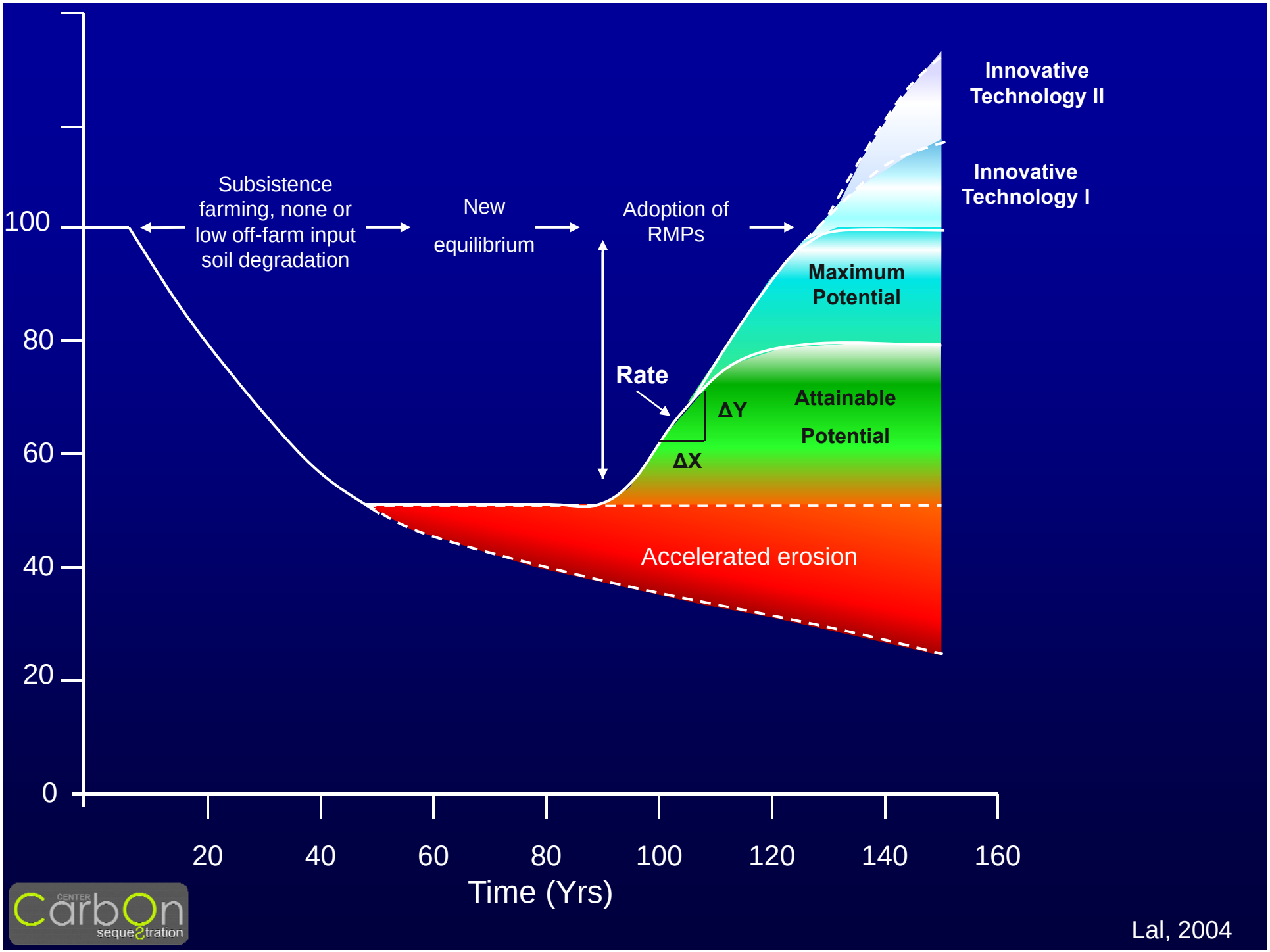
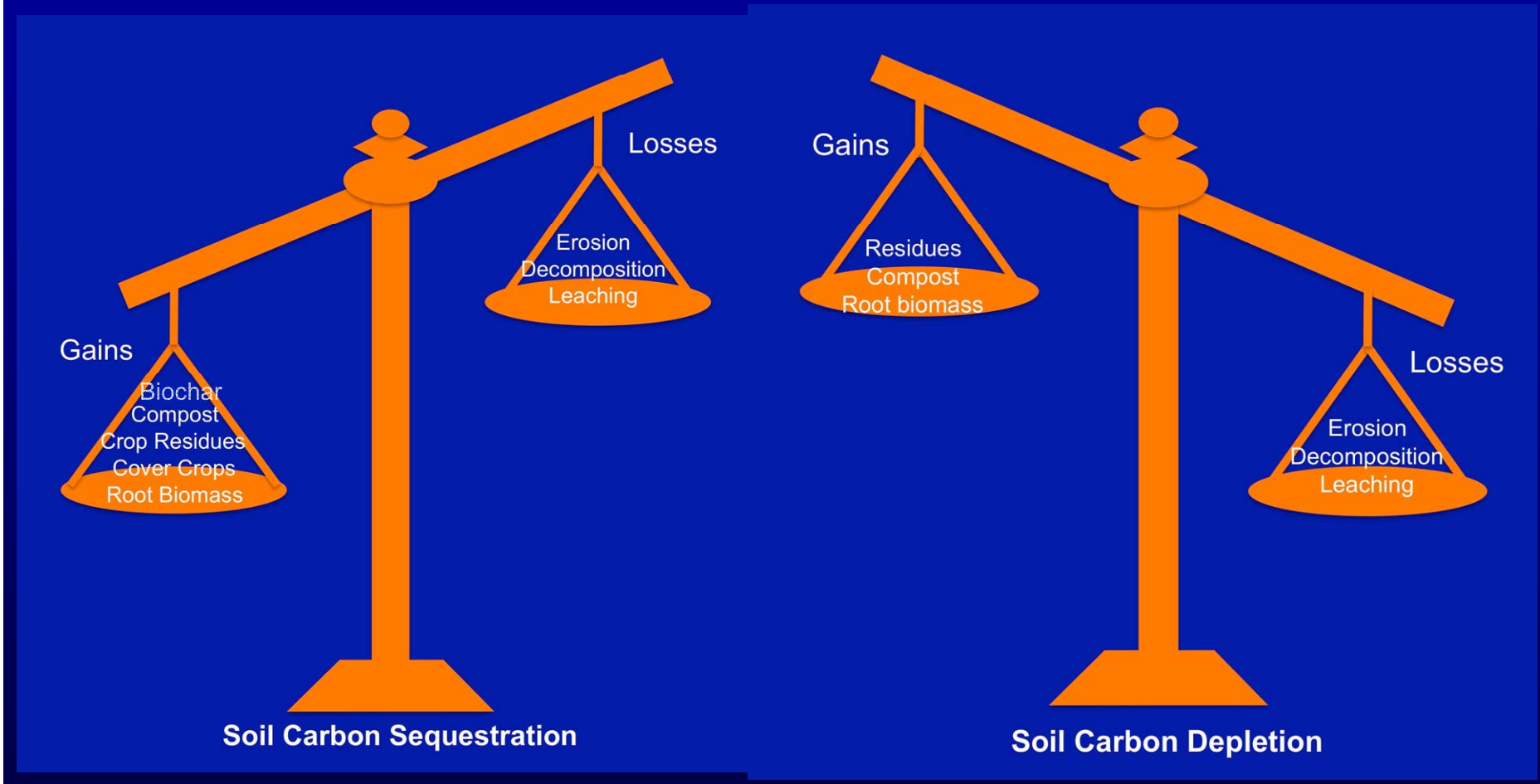

POSSIBLE STRATEGIES TO MANAGE CO_2 CONCENTRATION
Biosequestration
Business as Usual (BAU)
Zero Emission
Atmospheric Concentration of CO_2 (ppmv)
600
550
500
450
400
350
275
2010
2020
2030
2040
2050
2060
Time


Innovative Technology II
Innovative Technology I
Subsistence farming, none or low off-farm input soil degradation
New equilibrium
Adoption of RMPs
Maximum Potential
Rate
ΔY
ΔX
Attainable Potential
Accelerated erosion
100
80
60
40
20
0
20
40
60
80
100
120
140
160
Time (Yrs)
CarbOn sequestration
Lal, 2004

CREATING POSITIVE C BUDGET



Estimates of Global and Regional Potential of Soil C Sequestration

1. World: 0.6 - 1.2 Pg C yr^{-1}
2. USA: 144 - 432 Tg C yr^{-1}
3. India: 40 - 50 Tg C yr^{-1}
4. Iceland: 1.2 - 1.6 Tg C yr^{-1}
5. Brazil: 40 - 60 Tg C yr^{-1}
6. Western Europe: 70 - 190 Tg C yr^{-1}

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A Positive Nutrient Balance

A positive soil nutrient balance is essential to enhancing SOC pool and improving soil quality.

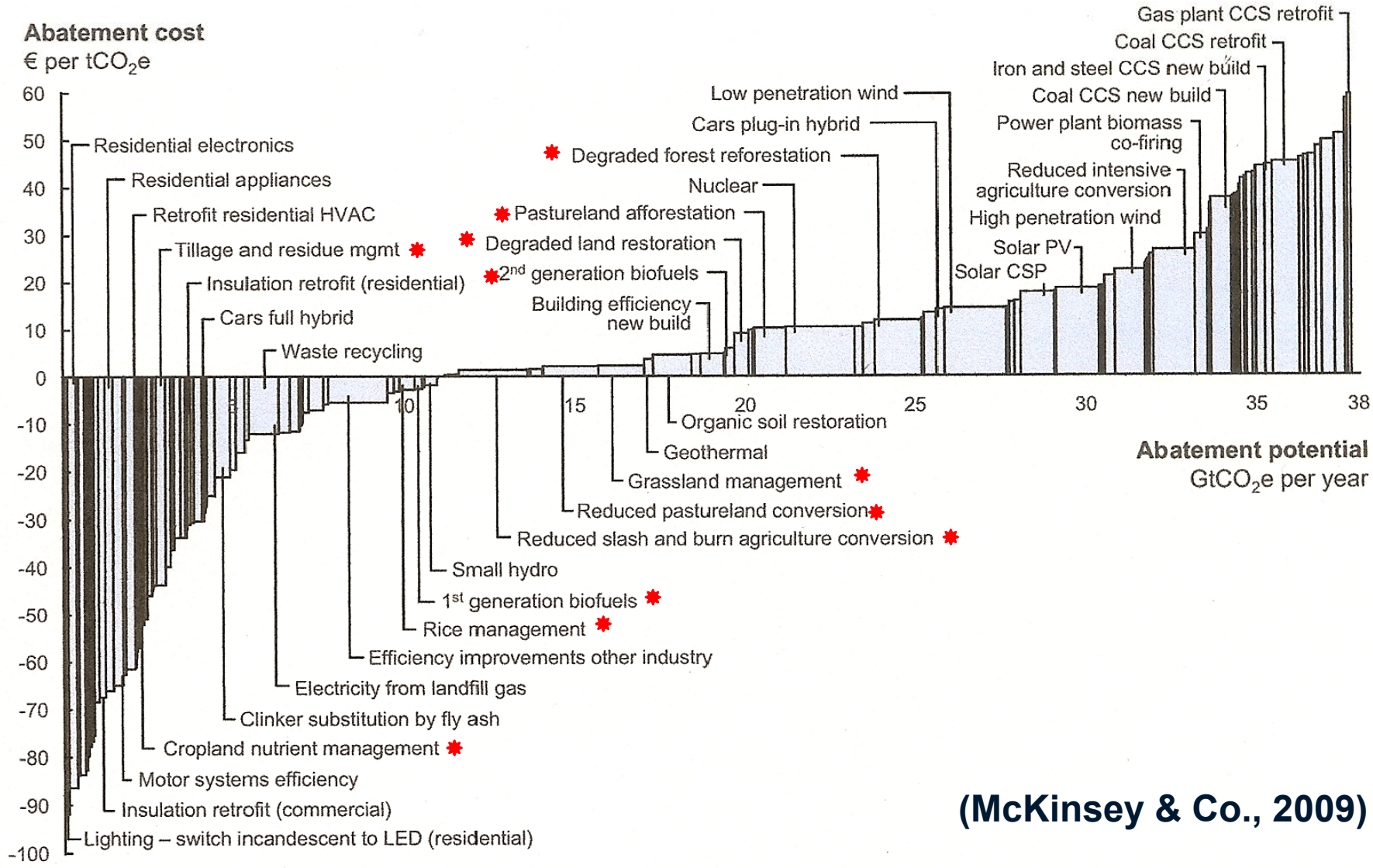
COMMODITIZATION OF SOIL C

How can soil C be made a commodity that can be traded like any other farm product?

TRADING C CREDITS

The C market may reach $ trillion by 2020. We need to make this market accessible to land managers.

Global GHG abatement cost curve beyond business-as-usual – 2030



(McKinsey & Co., 2009)

Price of CCS = $100-150/t CO_2 (Harvard Kennedy School, 2009)

TOTAL C POOL IN WORLD SOILS (JANZEN, 2005)

Ecosystem	Organic C Pool (Pg C to 1-m depth)			
	Range	Mean	% of Total	Flux (Gt C/yr)
Total in world soils	1395-2011	1580	100	60
Cropland soils	128-168	152	9.6	3
Grassland/Savannas	279-559	425	26.9	26
Plantations	-	90	5.7	5
Forests	-	704	44.5	17

57%

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FARMERS AND THE ENVIRONMENT

- Farmers have custody of more environment than does any other group.

- Farmers can address more global issues than any other group


CLIMATE CHANGE
- Mitigation
- Adaptation
FOOD SECURITY
- Quantity
- Quality
SOIL QUALITY & PROCESSES
WATER RESOURCES
- Quantity
- Quality
ENERGY DEMAND
- Use efficiency
- Biofuels
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FOOD GAP BY REGIONS

Region	Food Gap	
	2000	2010
	- - - - - - - - - 10^6 Mg/yr - - - - - - - -	
Sub-Saharan Africa	10.7	17.50
Latin America	0.63	0.99
Asia	1.70	3.63
Others	0.17	0.18
Total of 67 countries	13.20	22.30

(Shapouri, 2005)

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INCREASE IN FOOD PRODUCTION IN LDCS BY INCREASING SOC POOL BY 1 Mg C ha^{-1} yr^{-1}

Crop	Area (Mha)	Production Increase (10^6 Mg yr^{-1})
Cereals	430	21.8 - 36.3
Legumes	68	2.0 - 3.2
Tubers	34	6.6 - 11.3
Total	532	30.4 - 50.8

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LAW #1
CAUSES OF SOIL DEGRADATION

- The biophysical process of soil degradation is driven by economic, social and political forces.

- Vulnerability to degradation depends on "how" rather than "what" is grown.

LAW #2
SOIL STEWARDSHIP AND HUMAN SUFFERING

- When people are poverty stricken, desperate and starving, they pass on their sufferings to the land.

Law #3
NUTRIENT, CARBON AND WATER BANK

- It is not possible to take more out of a soil than what is put in it without degrading its quality.

- Only by replacing what is taken can a soil be kept fertile, productive, and responsive to inputs.

LAW #4
MARGINALITY PRINCIPLE

- Marginal soils cultivated with marginal inputs produce marginal yields and support marginal living.

- Recycling is a good strategy especially when there is something to recycle.

LAW #5
ORGANIC VERSUS INORGANIC SOURCE OF NUTRIENTS

- Plants cannot differentiate the nutrients supplied through inorganic fertilizers or organic amendments.

LAW #6
SOIL CARBON AND GREENHOUSE EFFECT

- Mining C has the same effect on global warming whether it is through mineralization of soil organic matter and extractive farming or burning fossil fuels or draining peat soils.

- Soil can be a source or sink of GHGs depending on land use and management.

LAW #7
SOIL VERSUS GERMPLASM

- The potential of elite varieties can be realized only if grown under optimal soil conditions.

- Even the elite varieties cannot extract water and nutrients from any soil where they do not exist.

Law #8
SOIL AS A SINK FOR ATMOSPHERIC CO_2

- Soil are integral to any strategy of mitigating global warming and improving the environment.

LAW #9
ENGINE OF ECONOMIC DEVELOPMENT

- Sustainable management of soils is the engine of economic development, political stability and transformation of rural communities in developing countries.

Law #10
TRADITIONAL KNOWLEDGE AND MODERN INNOVATIONS

- Sustainable management of soil implies the use of modern innovations built upon the traditional knowledge.

- Those who refuse to use modern science to address urgent global issues must be prepared to endure more suffering.

GANDHI'S 7 SINS OF HUMANITY.

1. Wealth without work
2. Pleasure without conscience
3. Knowledge without character
4. Commerce without morality
5. Politics without principle
6. Religion without sacrifice
7. Science without humanity

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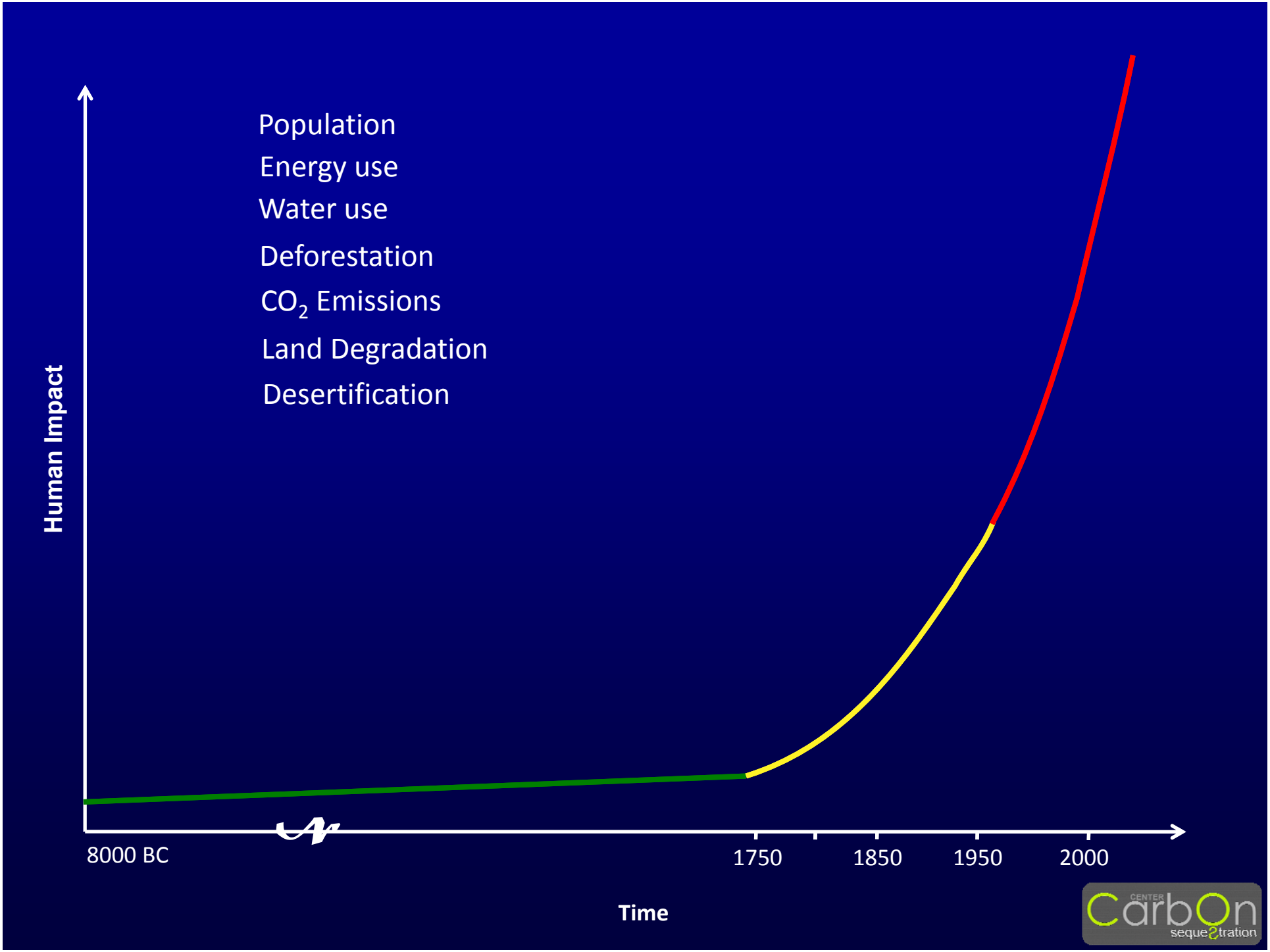
PRODUCTIVITY INCREASE BETWEEN 1900 AND 2000 (PONTING, 2007)

Parameter	Increase Factor Between 1900-2000
Population	3.8
Urban Population	12.8
Industrial output	35
Energy Use	12.5
Oil Production	300
Water Use	9
Irrigated Area	6.8
Fertilizer Use	342
Fish Catch	65
Organic Chemicals	1000
Car Ownership	7750


Population
Energy use
Water use
Deforestation
CO_2 Emissions
Land Degradation
Desertification
Human Impact
8000 BC
1750
1850
1950
2000
Time
CarbOn
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seque2tration

SINS OF HUMANITY CONTINUED…

8. Technology without wisdom

9. Education without relevance

10. Humanity without conscience