Carbon Management: Overview of Biotic Approaches

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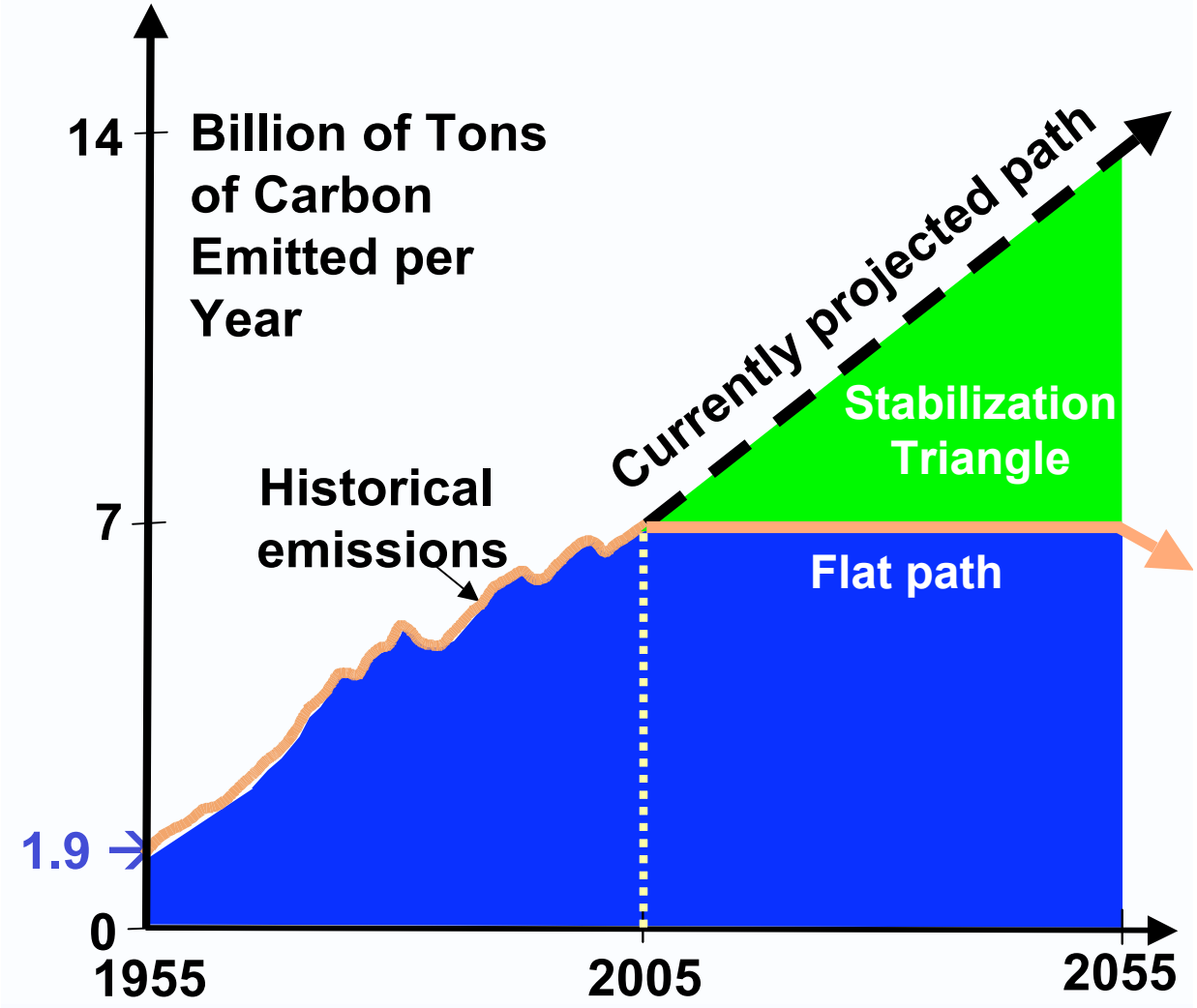
CO_2 Emission Stabilization



Pacala & Socolow (2004)

Emission reduction

switch to better technologies with lower emissions

Energy substitution

renewable sources replace fossil fuels

Sequestration

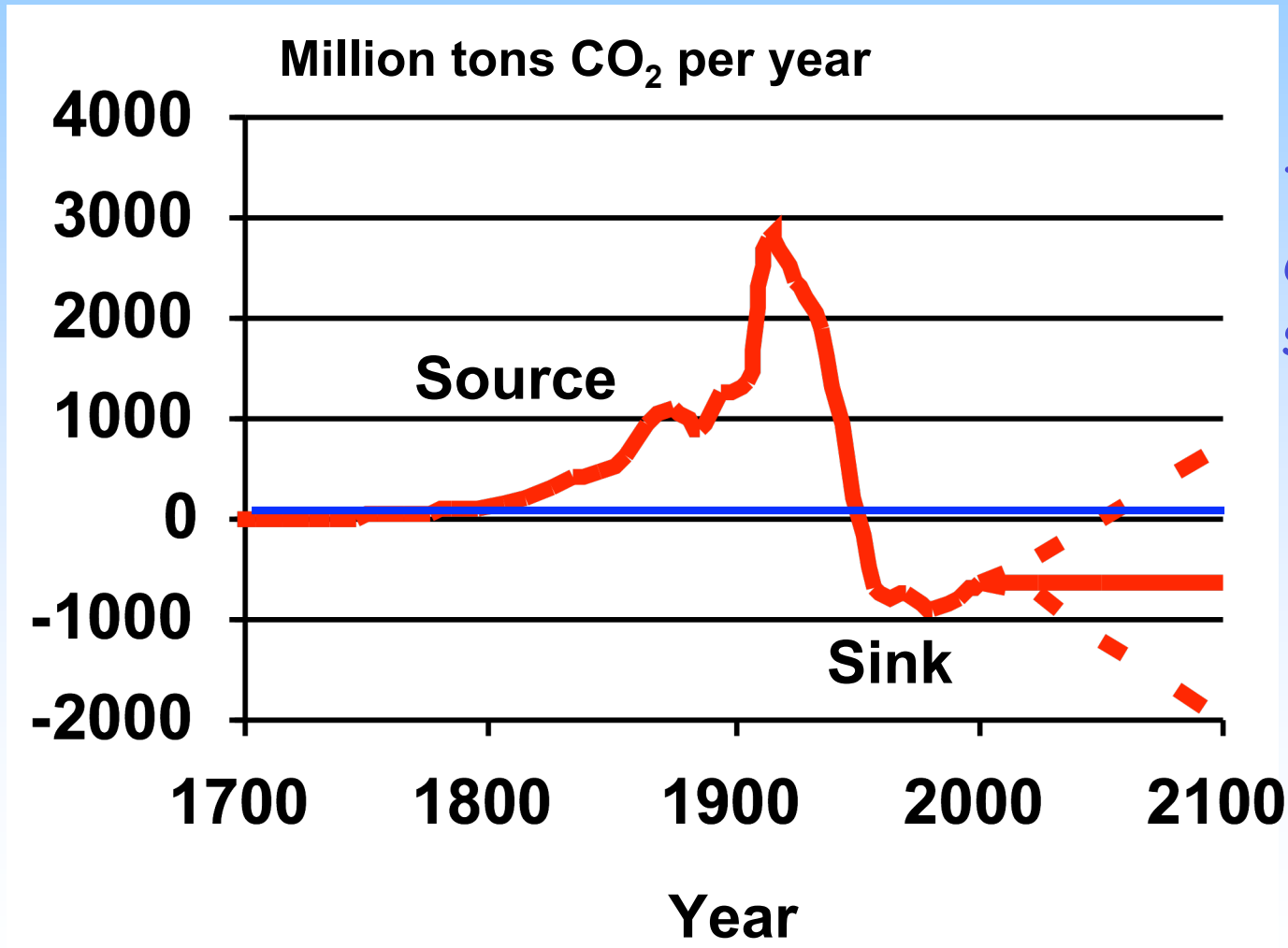
geological reservoirs

biotic uptake

- forestry
- agriculture
- ocean iron fertilization

Carbon Budget of the U.S. Forest Sector

(Forest Ecosystems and Wood Products)



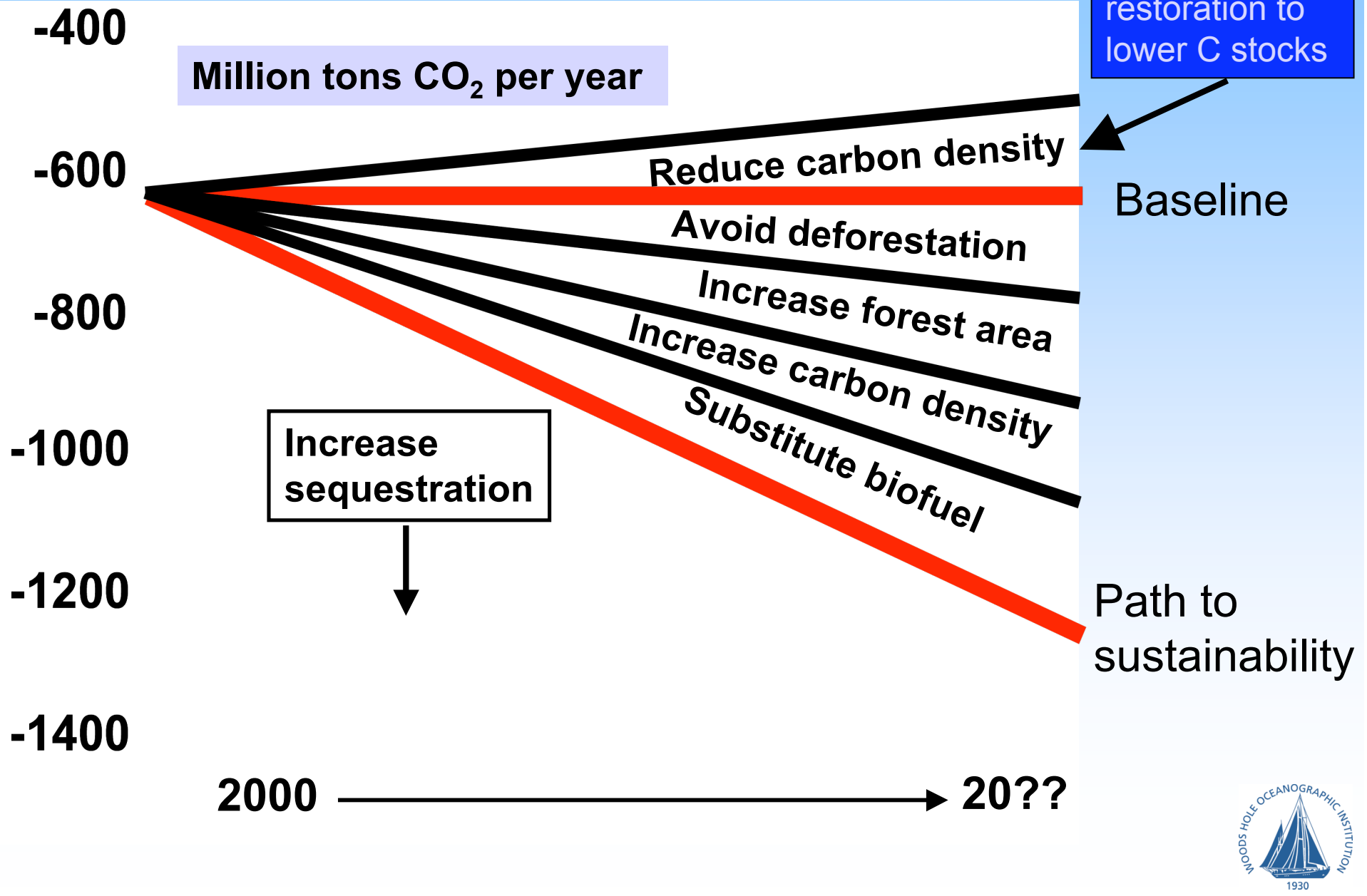
Threats could change sink to source!

?

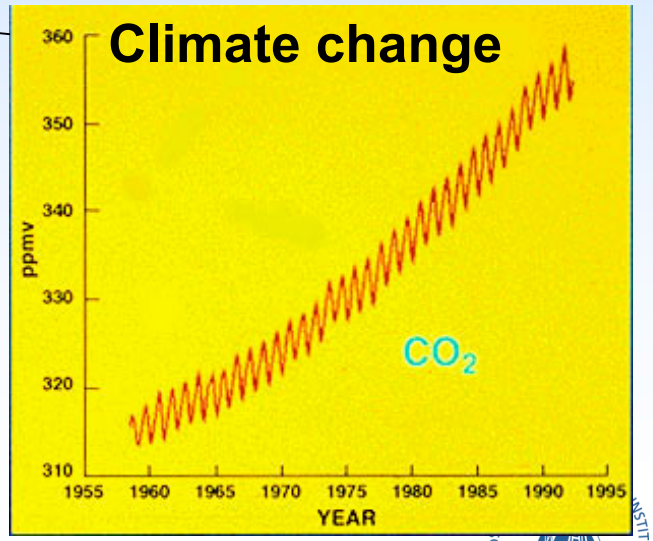
Actions could enhance sink strength

Birdsey 2006

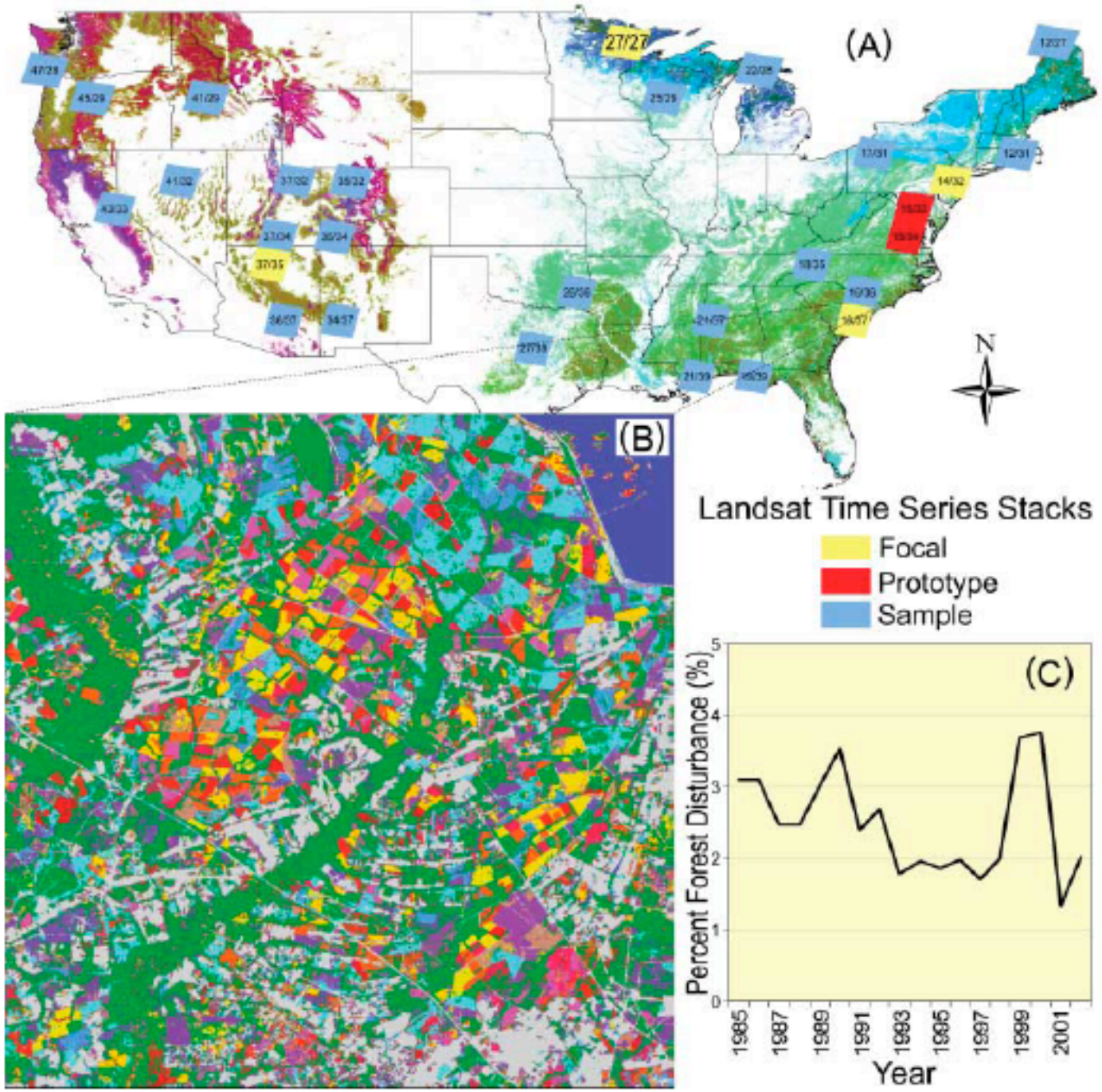
Forestry Activities to Increase Sequestration or Reduce Emissions



Permanence, Risk & Resilience



Land-use & Disturbance



Use satellite imagery to identify disturbance:

- AVHRR
- MODIS
- Landsat

Look for change in frequency

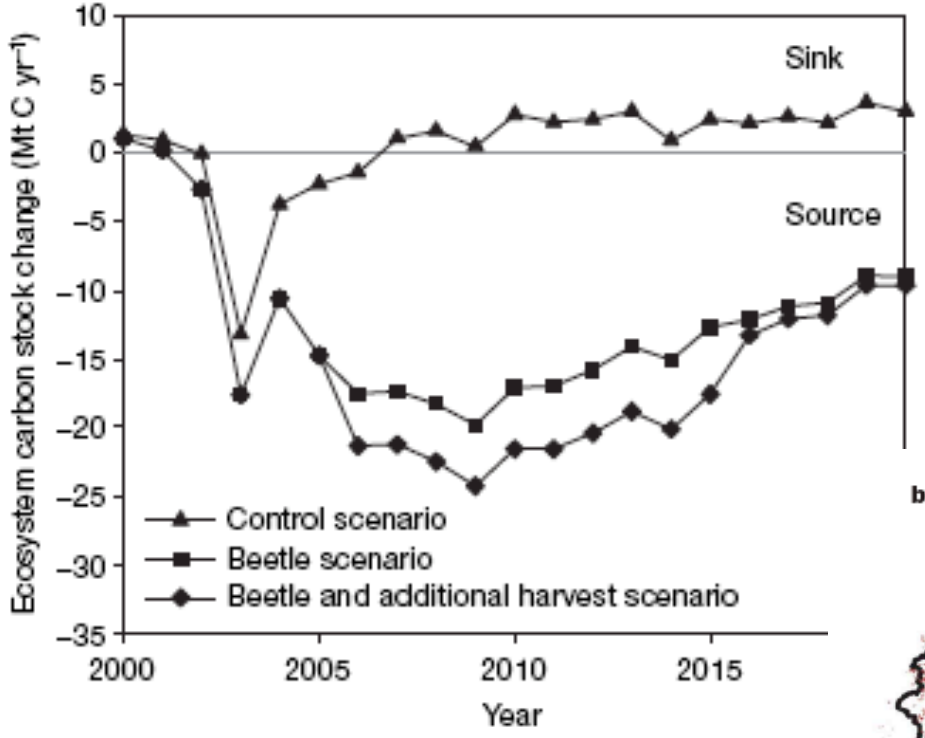
Goward et al., EOS (2008)

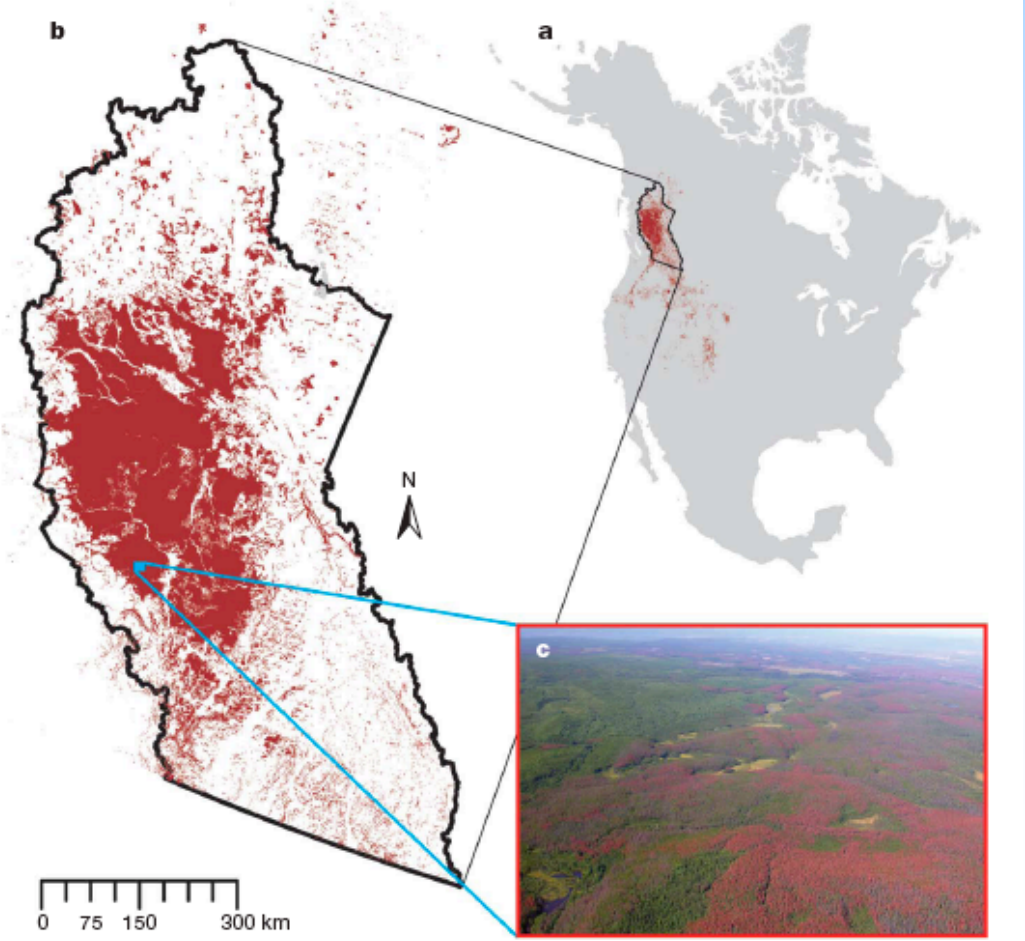
WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

Climate-Insect Synergy

-Mountain pine beetle outbreak linked to warming

-Cumulative emission of 270 Mton C (2000-2020)

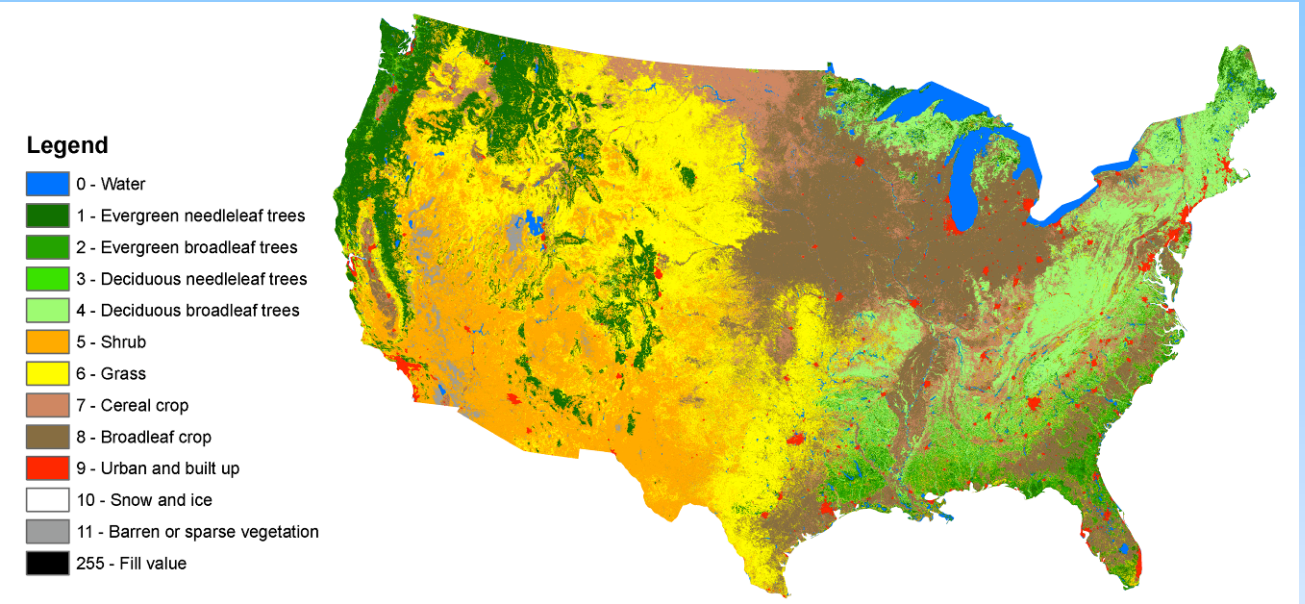




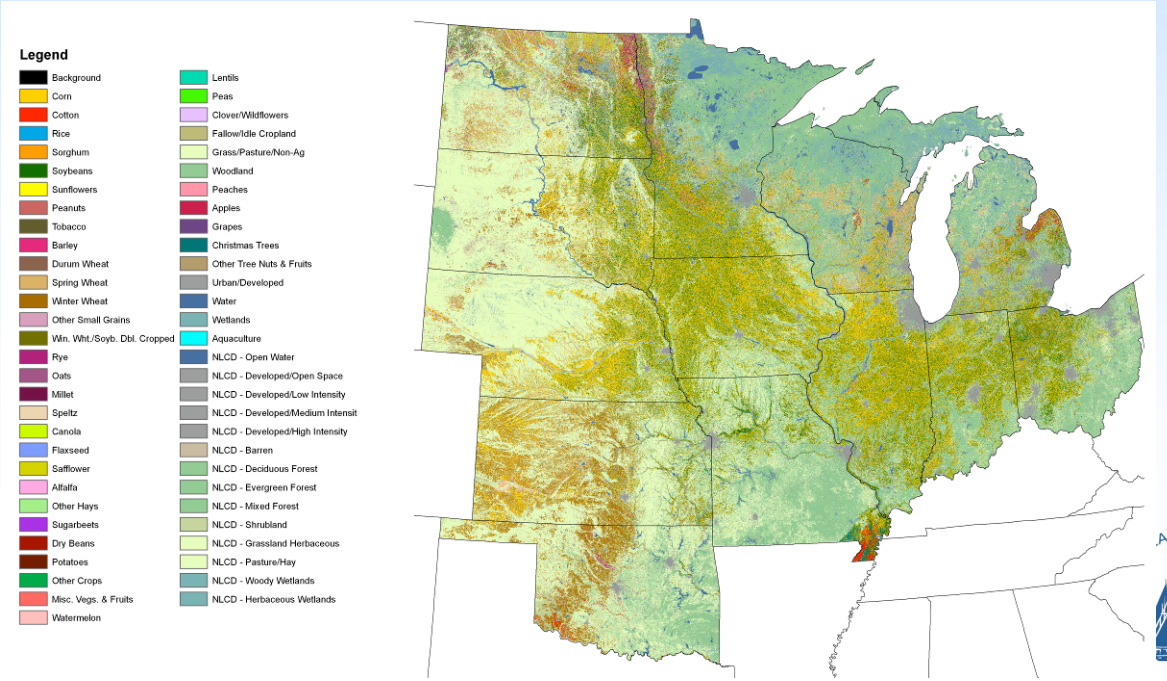
Kurz et al., Nature (2008)

Agricultural Land-Use Data

MODIS Land Use for United States (2000-2004)



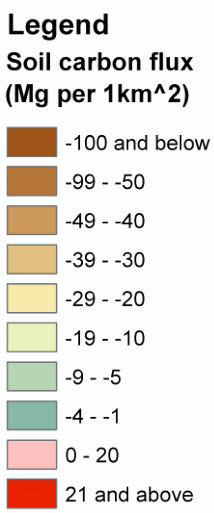
USDA-Cropland Data Layer, NACP Mid-Continent Intensive (2007)

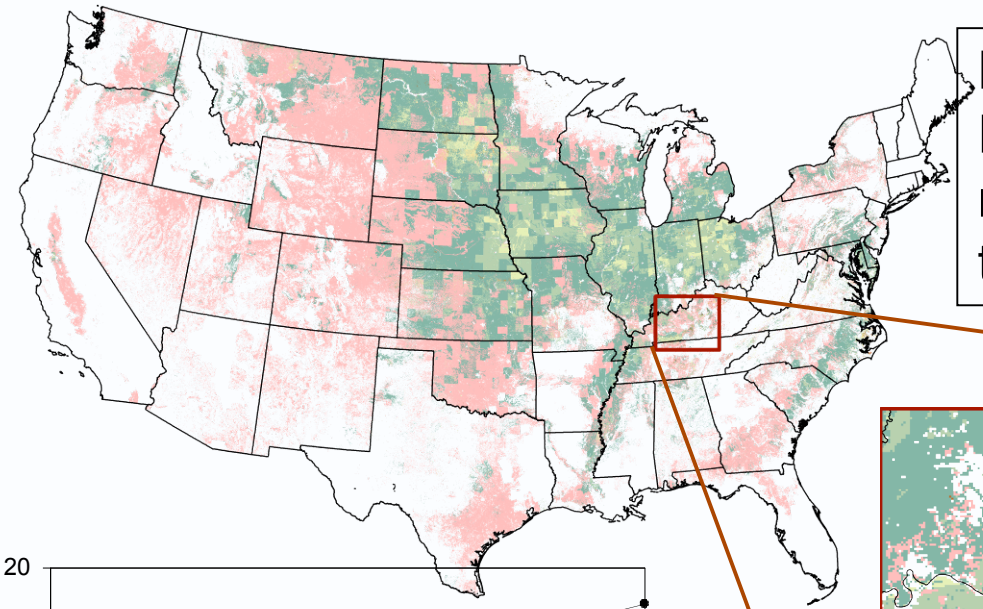


West et al.

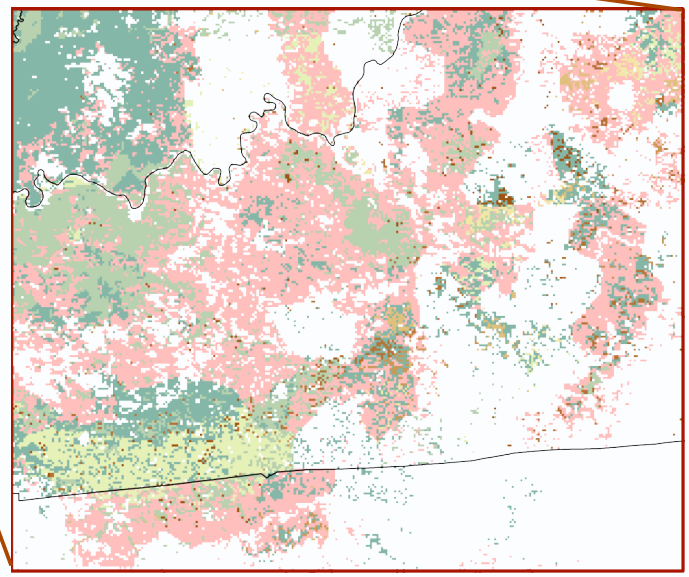
ANOGRAPHIC INSTITUTION
1930

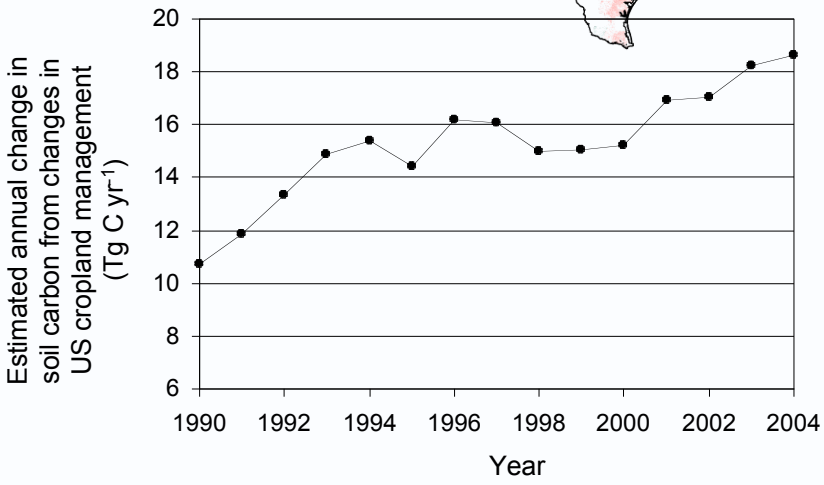
Soil carbon change associated with agronomic land management





Net negative flows FROM the atmosphere, net positive flows TO the atmosphere.





Estimates based on methods by West et al. (2008) using MODIS land cover

OAK RIDGE National Laboratory

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Multiple Benefit Projects (Climate & Poverty Reduction)

Restoration planting

Biofuels

Agroforestry

Community forestry

Carbon is now a commodity that can be grown on farms

Internationally carbon markets leveraged as poverty reduction tool

Skole et al.

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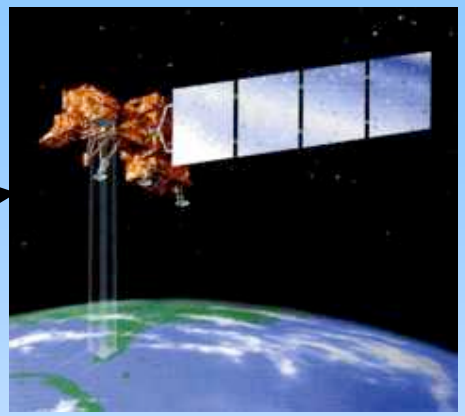
Integrated Monitoring, Decision Support & C Accounting



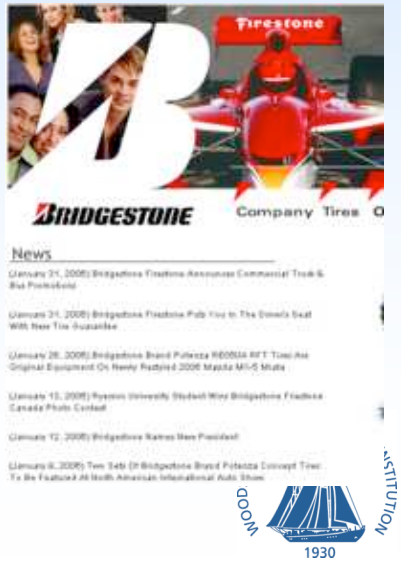
Earth Observation System

Carbon Sellers

Satellite Database Data Analysis

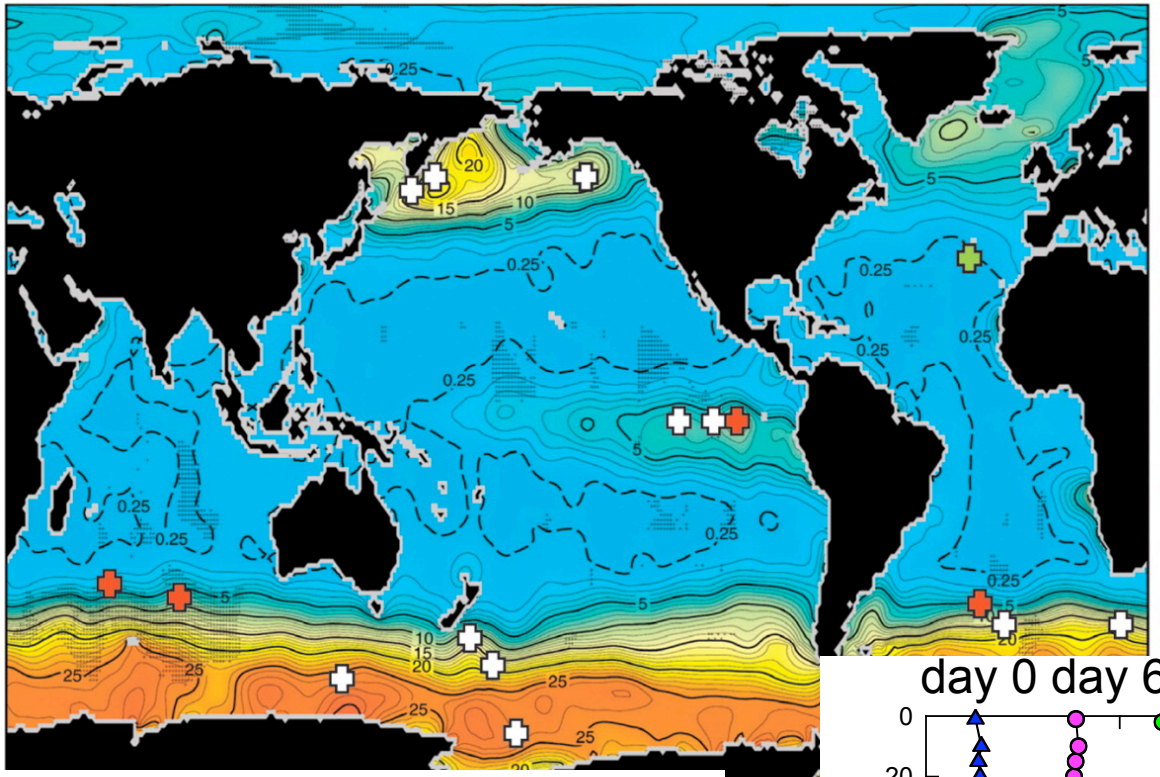
Carbon Models Carbon Accounts

WWW



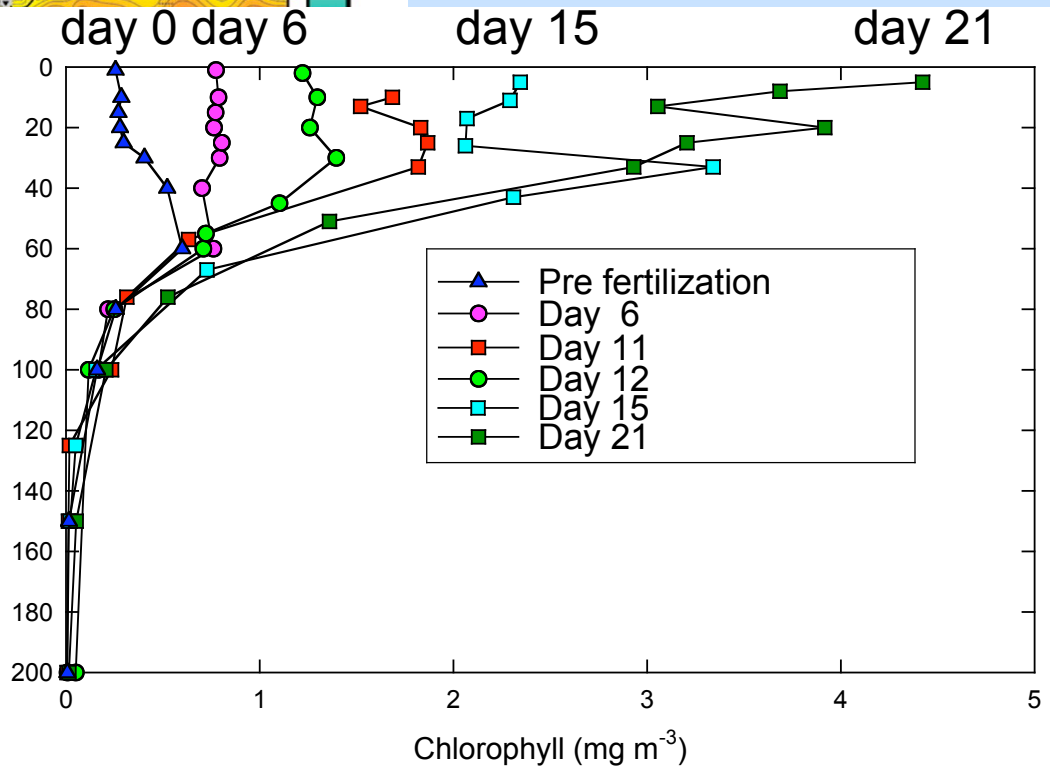
Markets Buyers

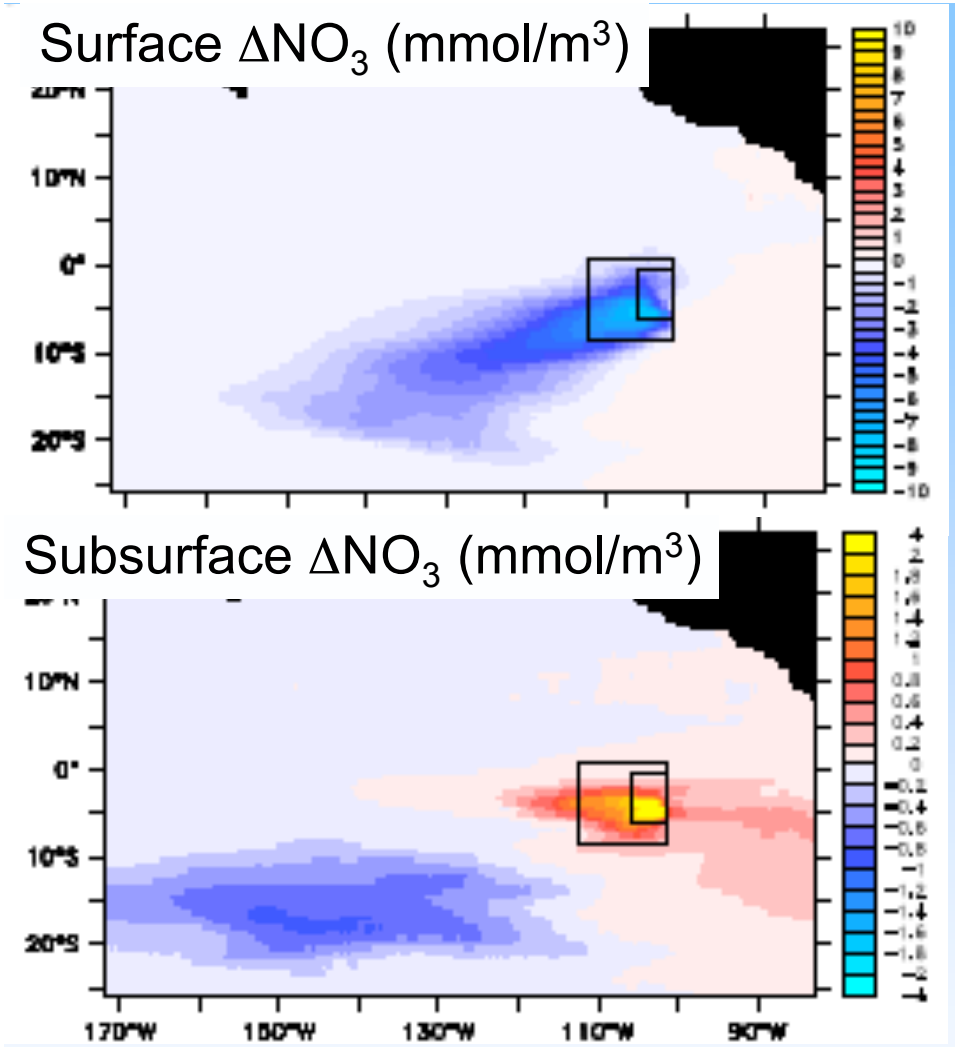
Deliberate iron fertilization

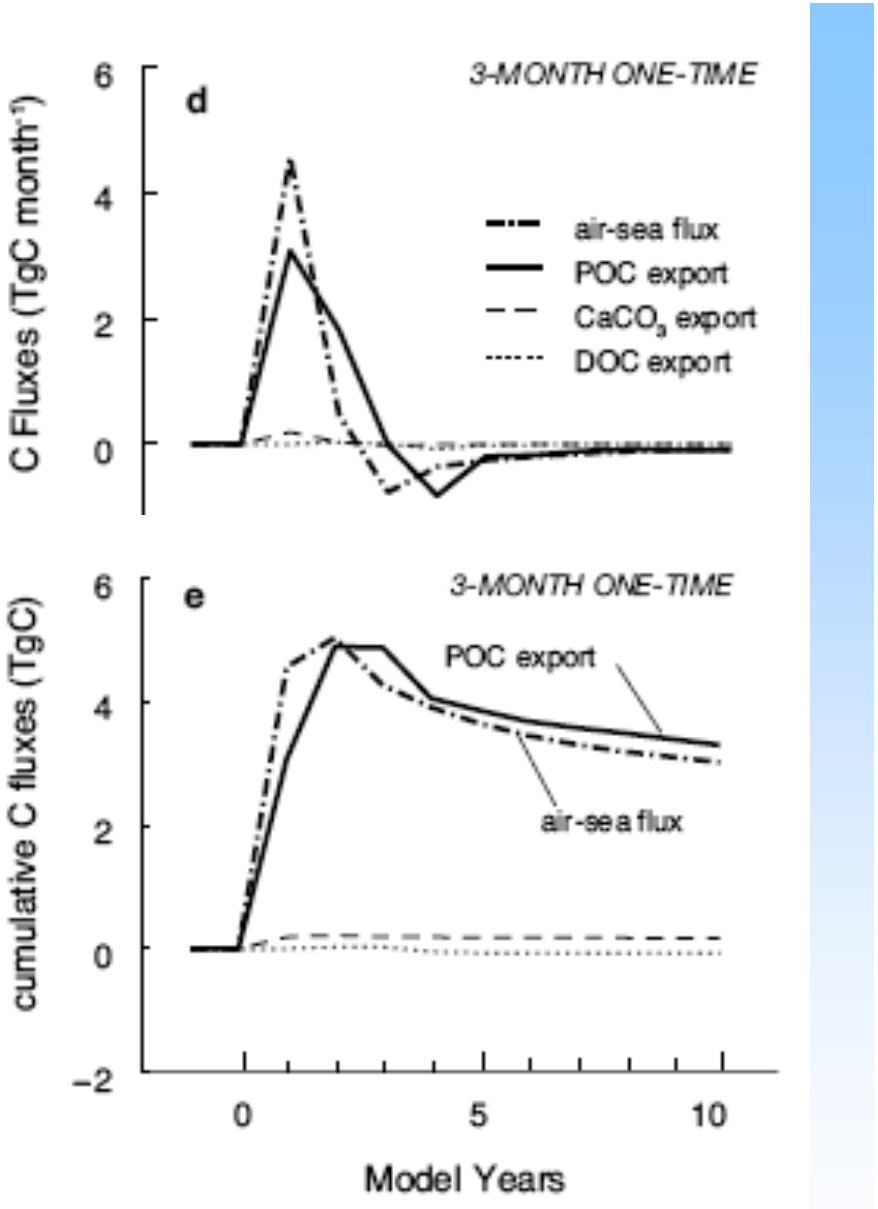


Boyd et al. Science (2007)

12 iron perturbation experiments in High Nitrate Low Chlorophyll (HNLC) areas







- Stimulate growth
- Enhance C flux to deep-sea?
- Permanace (depth, circulation, iron scavenging)
- Verification & additionality (models)

Jin et al. Biogeosciences 2008

POLICYFORUM

Buesseler et al.
Science, 2008

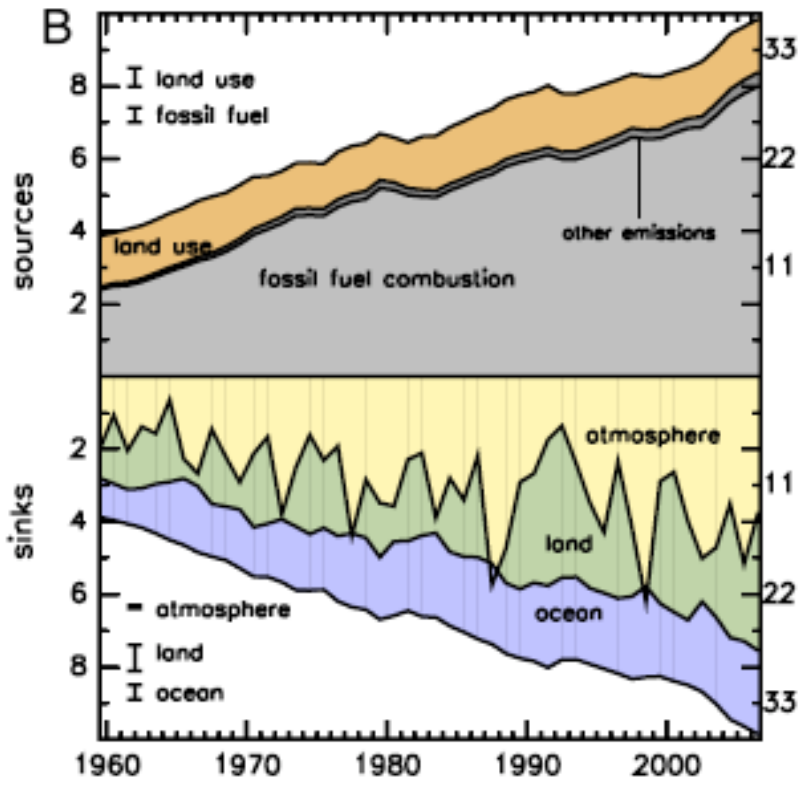
ENVIRONMENT

Ocean Iron Fertilization—Moving Forward in a Sea of Uncertainty

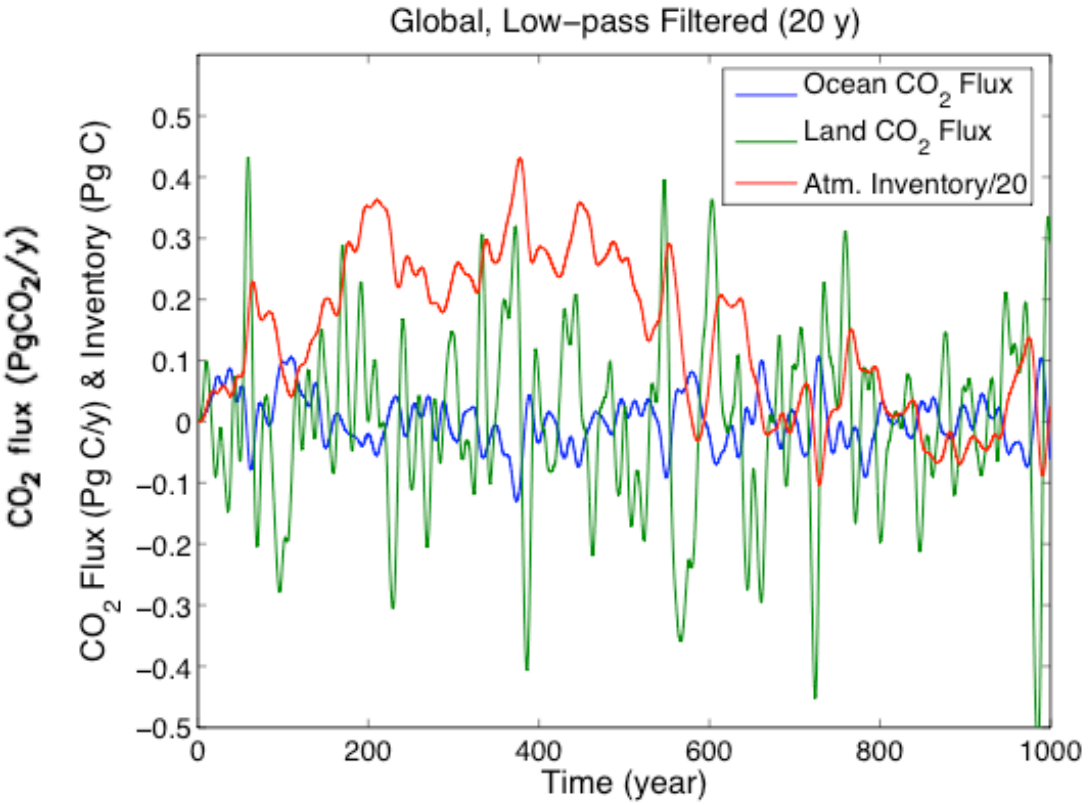
Ken O. Buesseler,[1]* Scott C. Doney,[1] David M. Karl,[2] Philip W. Boyd,[3] Ken Caldeira,[4] Fei Chai,[5] Kenneth H. Coale,[6] Hein J. W. de Baar,[7] Paul G. Falkowski,[8] Kenneth S. Johnson,[9] Richard S. Lampitt,[10] Anthony F. Michaels,[11] S. W. A. Naqvi,[12] Victor Smetacek,[13] Shigenobu Takeda,[14] Andrew J. Watson[15]

"premature to sell carbon offsets from the first generation of commercial-scale OIF experiments unless there is better demonstration that OIF effectively removes CO_2, retains that carbon in the ocean for a quantifiable amount of time, and has acceptable and predictable environmental impacts."

Ocean Damping of Carbon Mitigation



Canadell et al., PNAS (2007)



Doney et al., J. Climate (2006)

-global ocean/atm (land) coupled on low frequencies
-C mitigation => atm. CO_2 decrease => ocean CO_2 release
-ocean damps ~20-25% (or more) on multi-decade

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Carbon Trading

-"C tax" & "cap & trade"

-compulsory (EU) & voluntary (Chicago Climate Exchange)

-traded in tons CO_2 (1t CO_2 = 0.27t C)

-

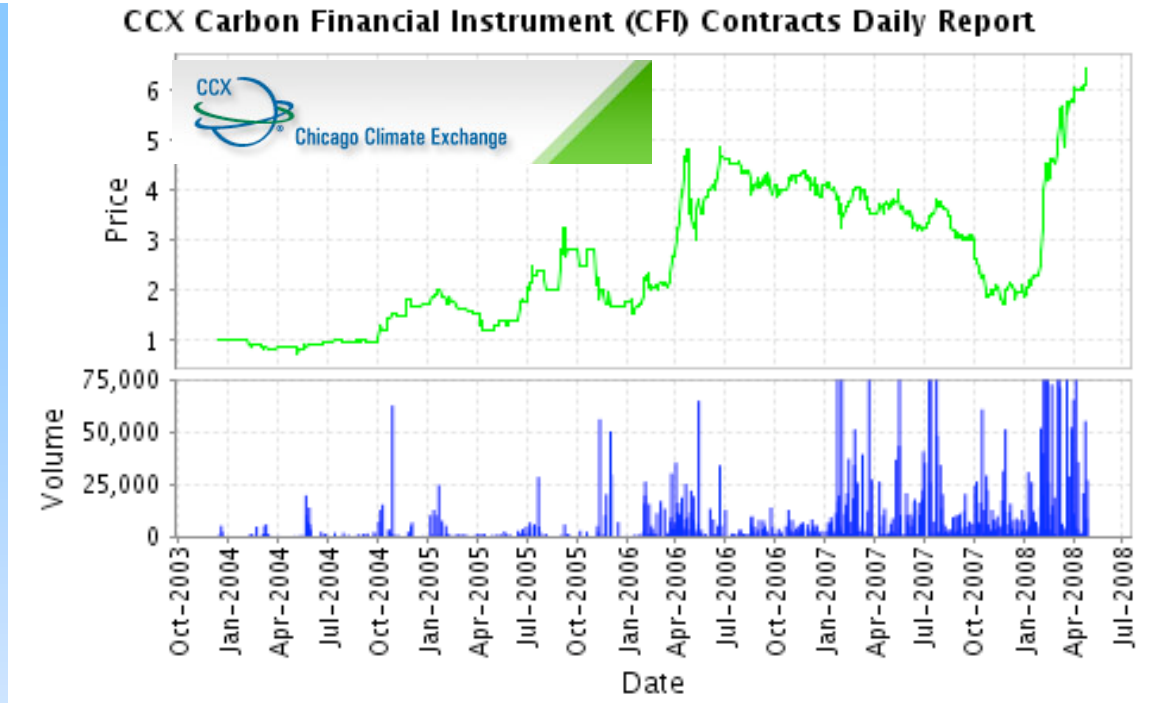
Methane (agriculture, coal mine & landfill)

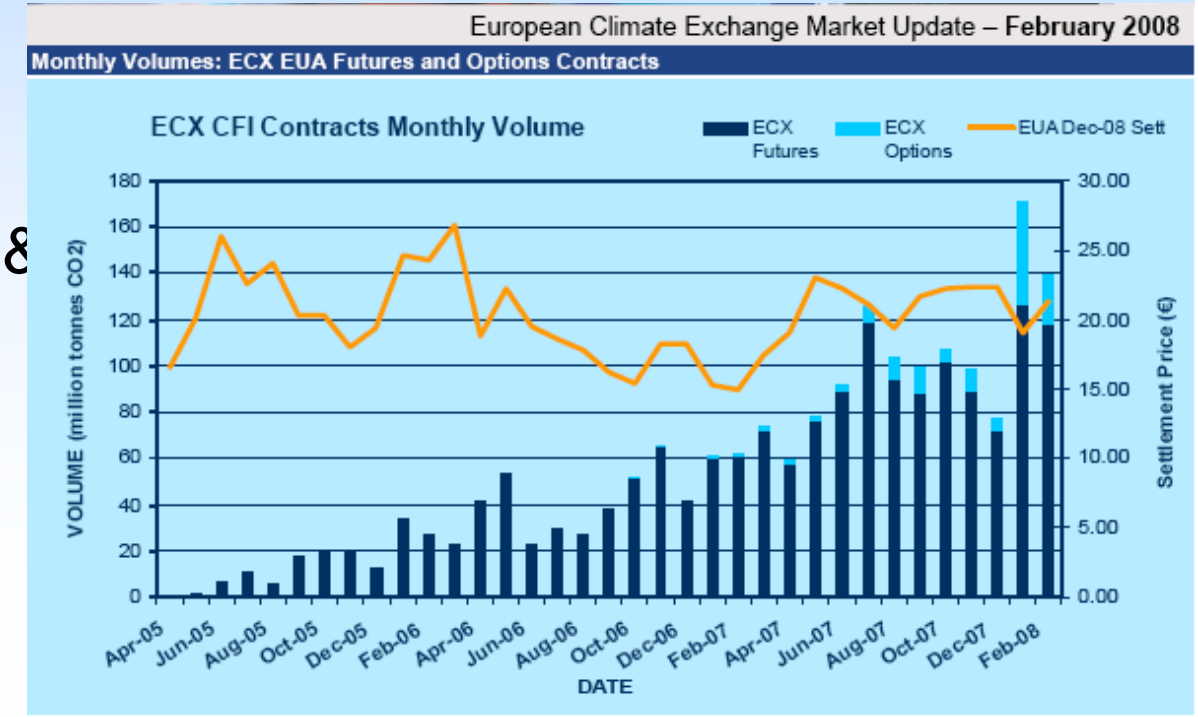
Soil carbon (agriculture & rangeland)

Forestry

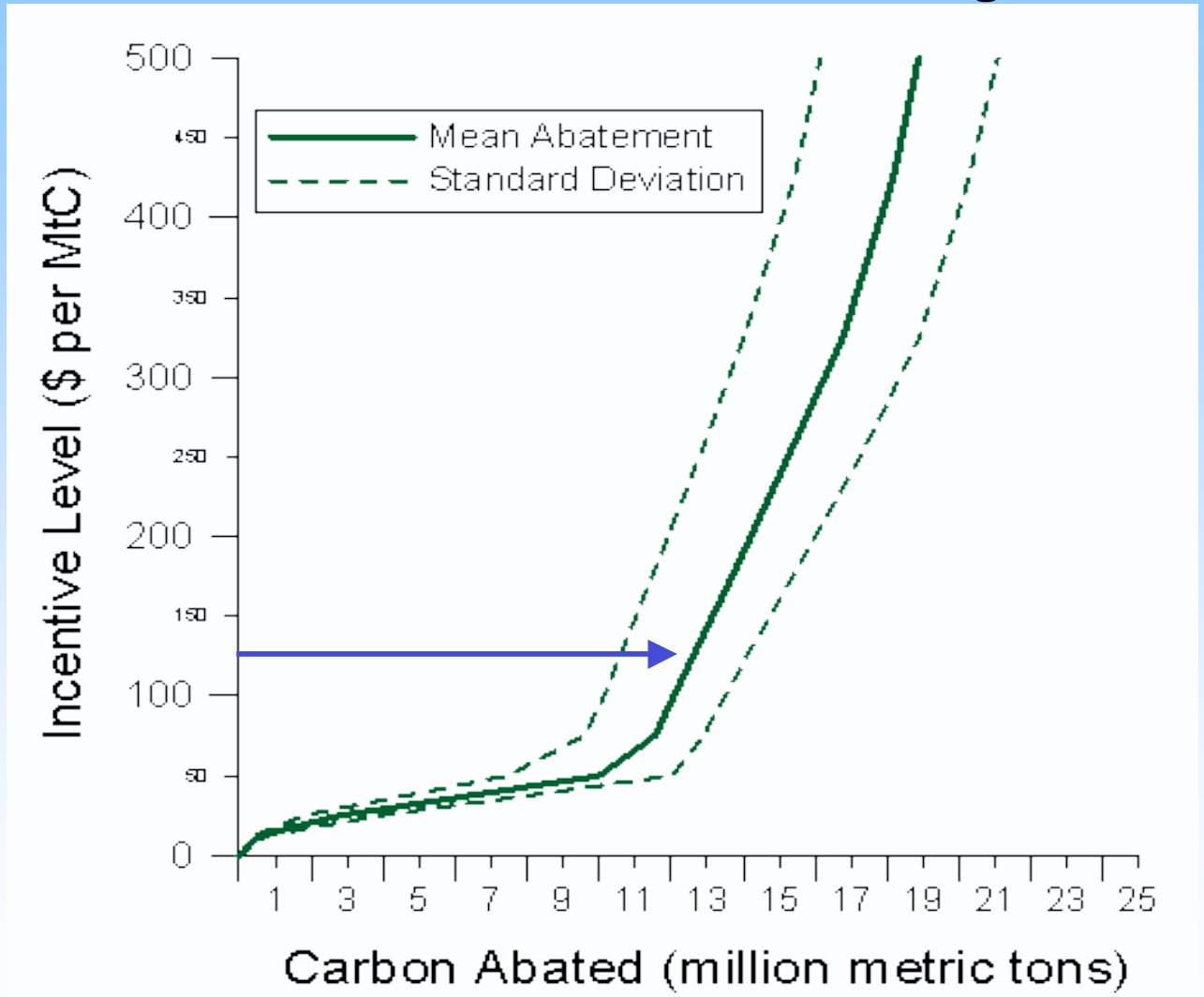
Renewable energy

Ozone depleting substance destruction





Regional changes from bioeconomics model for combined soil carbon and fossil-fuel carbon (no-tillage case; 2025)



OAK RIDGE National Laboratory

Agricultural Policy Analysis Center
University of Tennessee

Hellwinckel, CM (2008) Dissertation, University of Tennessee, May.

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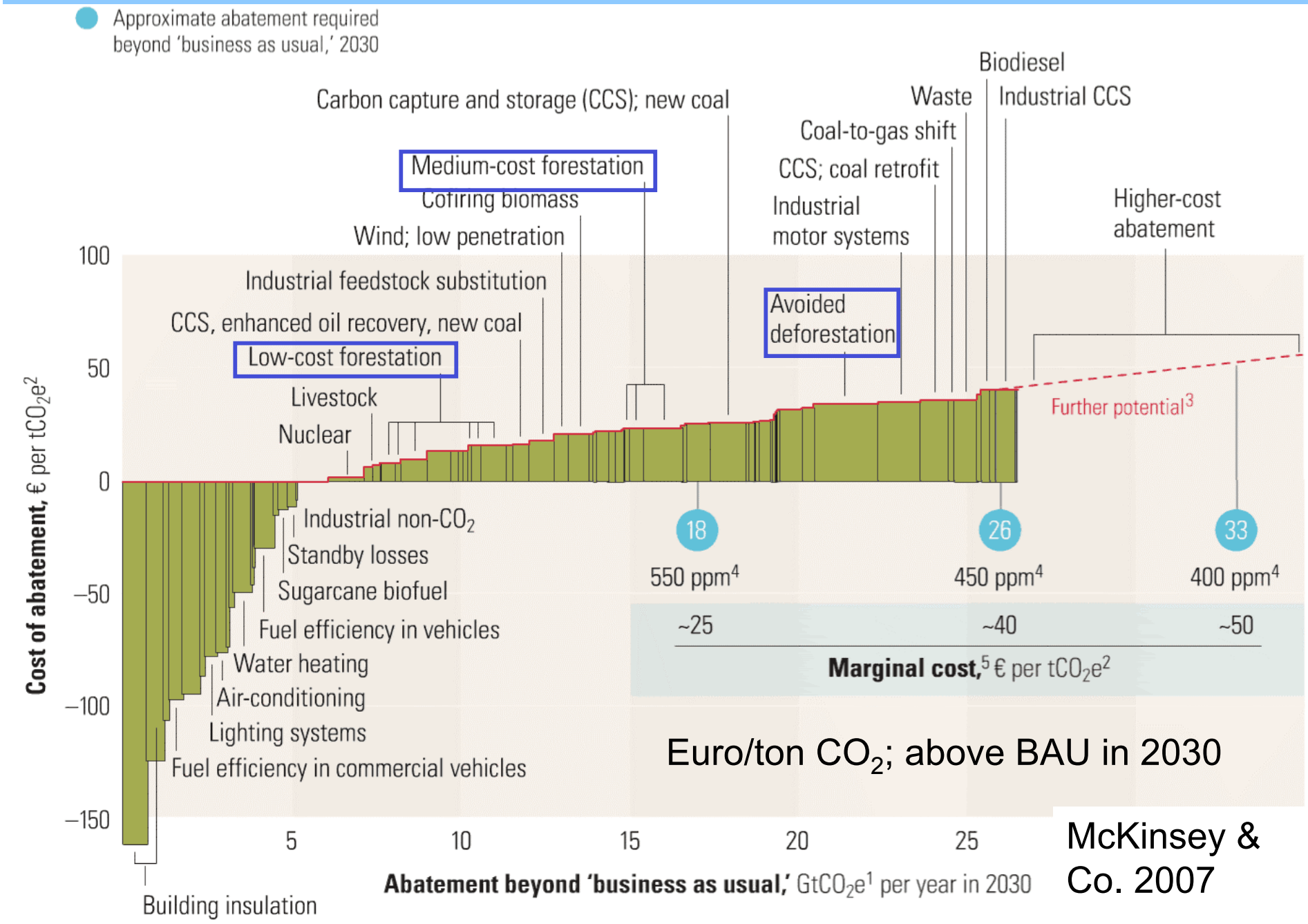
CO_2 Abatement Costs



Euro/ton CO_2; above BAU in 2030

McKinsey & Co. 2007

Criteria for Assessing Biotic C Sequestration

- Efficacy & Permanace
  - -does it sequester carbon & for how long?
  - -release other climate-relevant gases (CH_4, N_2O)
- Verification
  - -standard methodologies & monitoring
  - -additionality & downstream effects
- Environmental consequences
  - -intended change in biomass & community structure
  - -unintended biological impacts?
- Economic, legal & political framework
  - -abatement cost curves ($/ton CO2)
  - -decision support tools & case studies
  - -voluntary & regulated carbon markets
  - -post-Kyoto frameworks (international, US, …)
  - -social benefits & drawbacks