



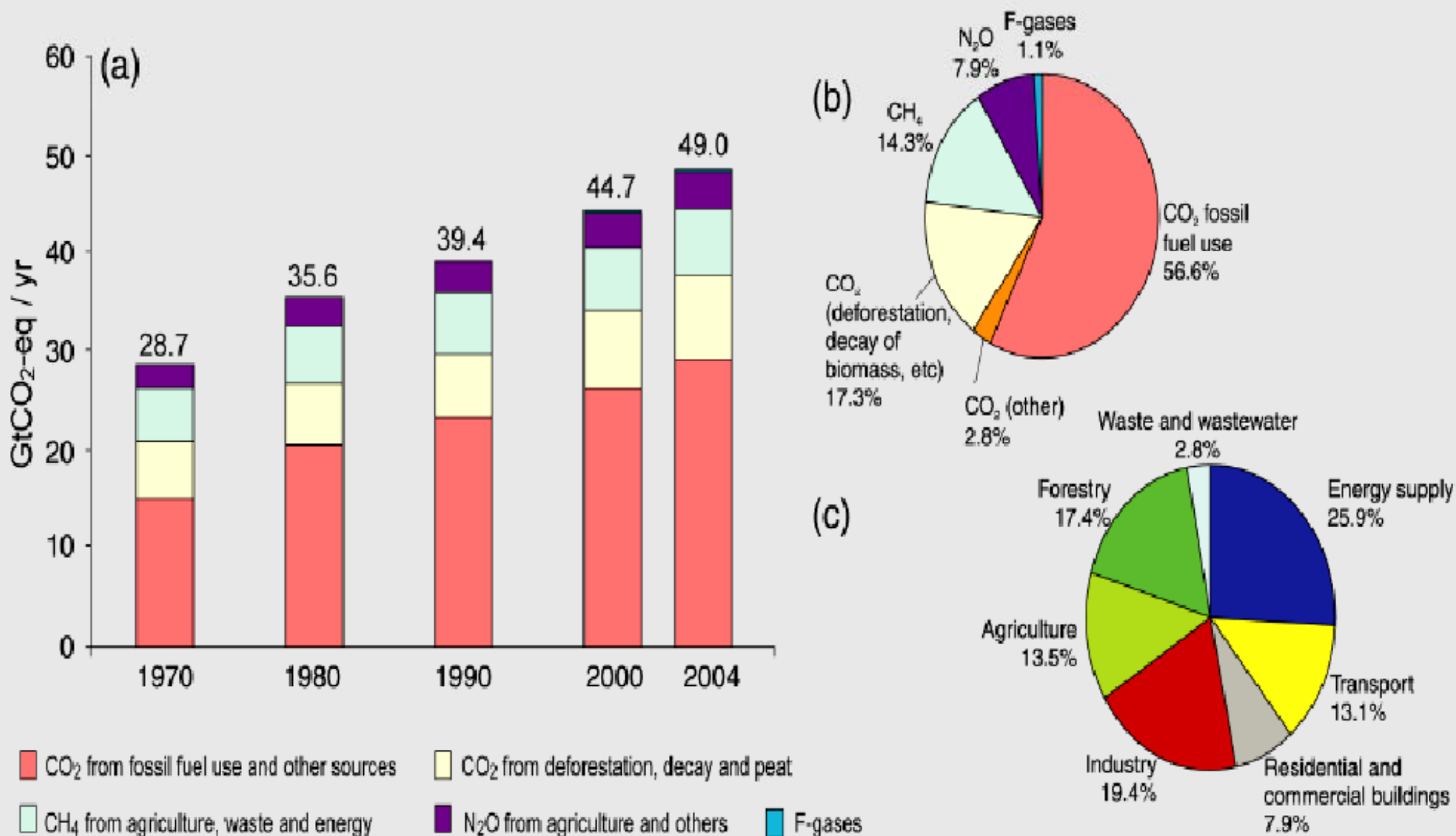
Greenhouse Gases: Soil Science, Terrestrial Sequestration, and Agricultural Offsets

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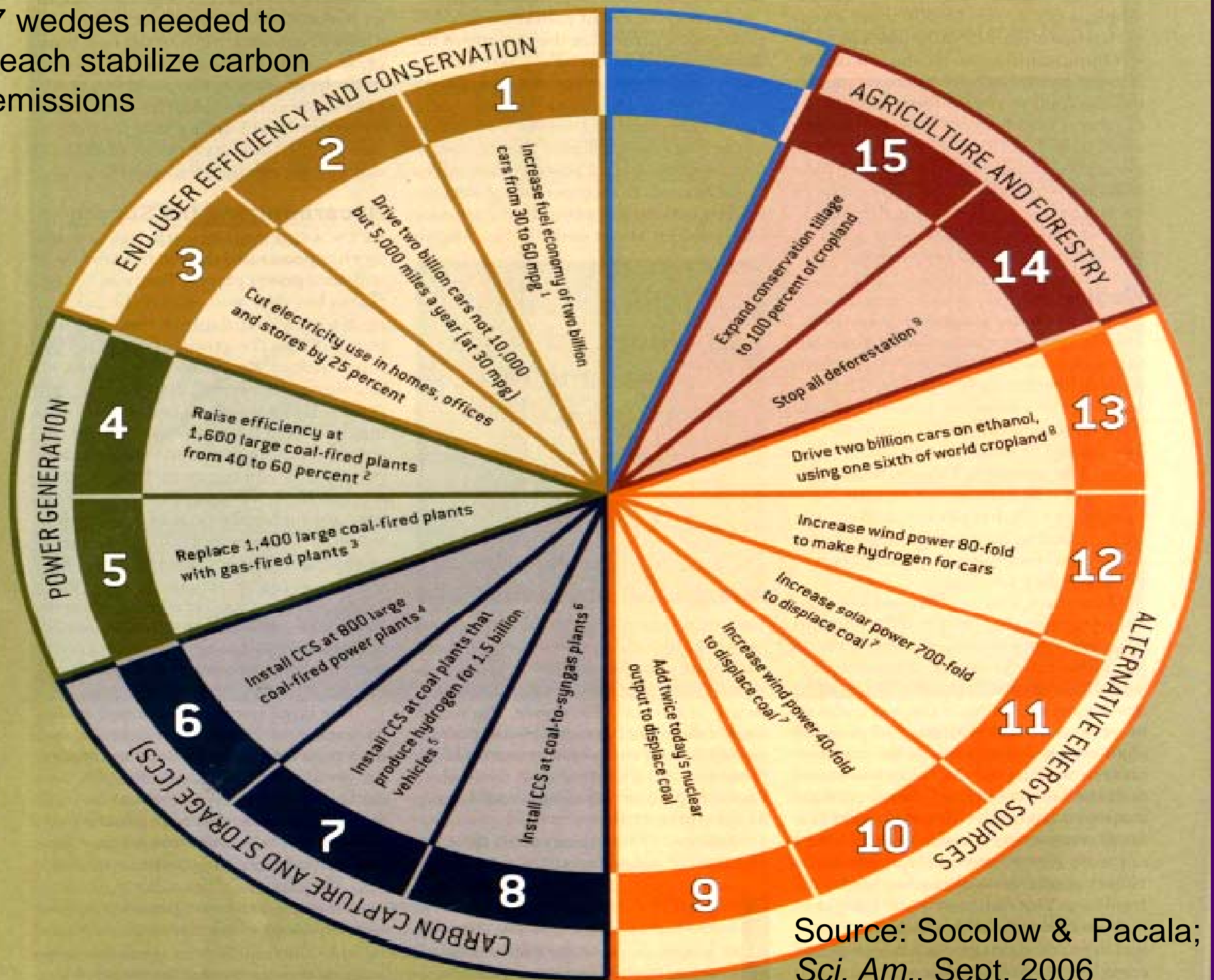
K-State Research and Extension

Figure SPM.3. (a) Global annual emissions of anthropogenic GHGs from 1970 to 2004. (b) Share of different anthropogenic GHGs in total emissions in 2004 in terms of CO₂-eq. (c) Share of different sectors in total anthropogenic GHG emissions in 2004 in terms of CO₂-eq. (Forestry includes deforestation). {Figure 2.1}



Mitigation

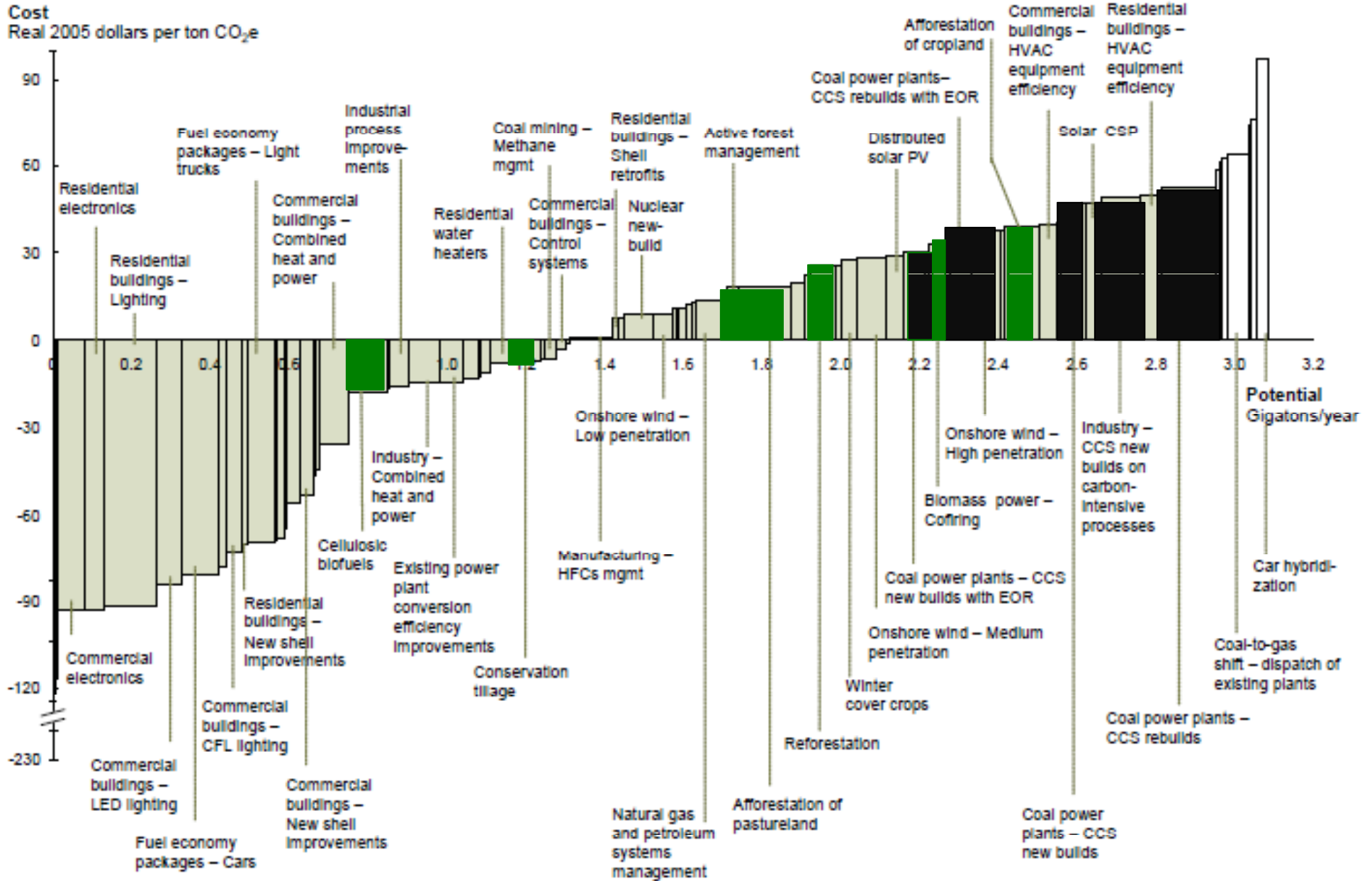
7 wedges needed to reach stabilize carbon emissions



Source: Socolow & Pacala; Sci. Am., Sept. 2006

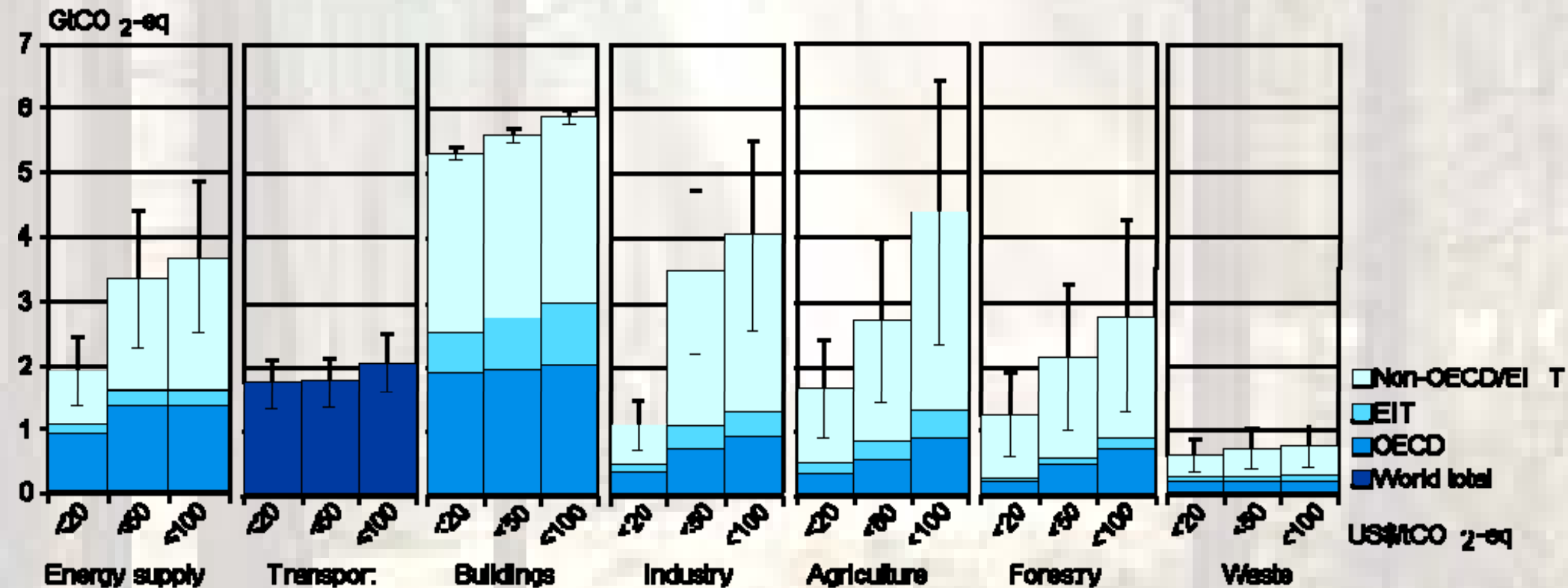
U.S. MID-RANGE ABATEMENT CURVE – 2030

Abatement cost <\$50/ton



Source: McKinsey analysis

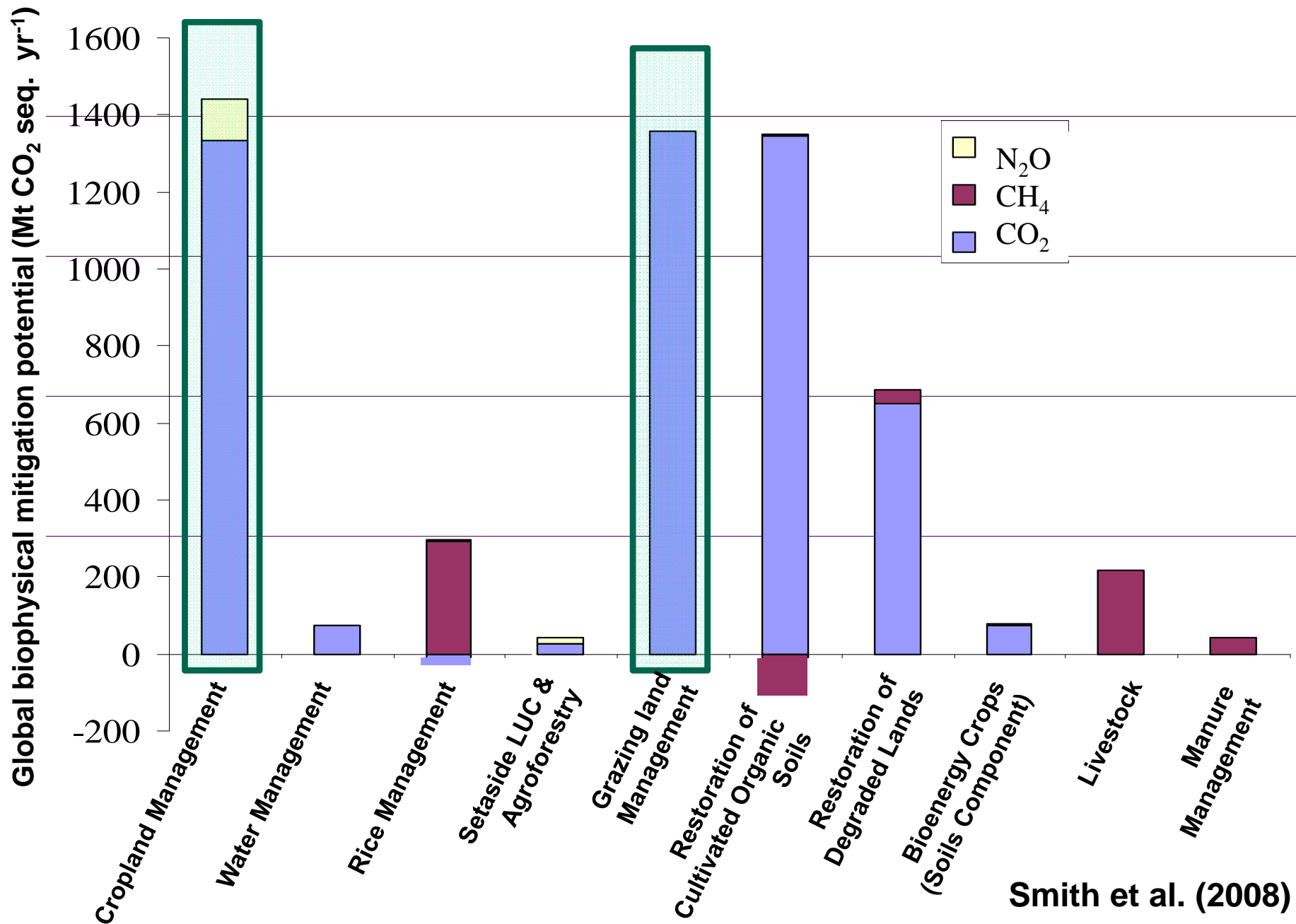
Global economic mitigation potential for different sectors at different carbon prices

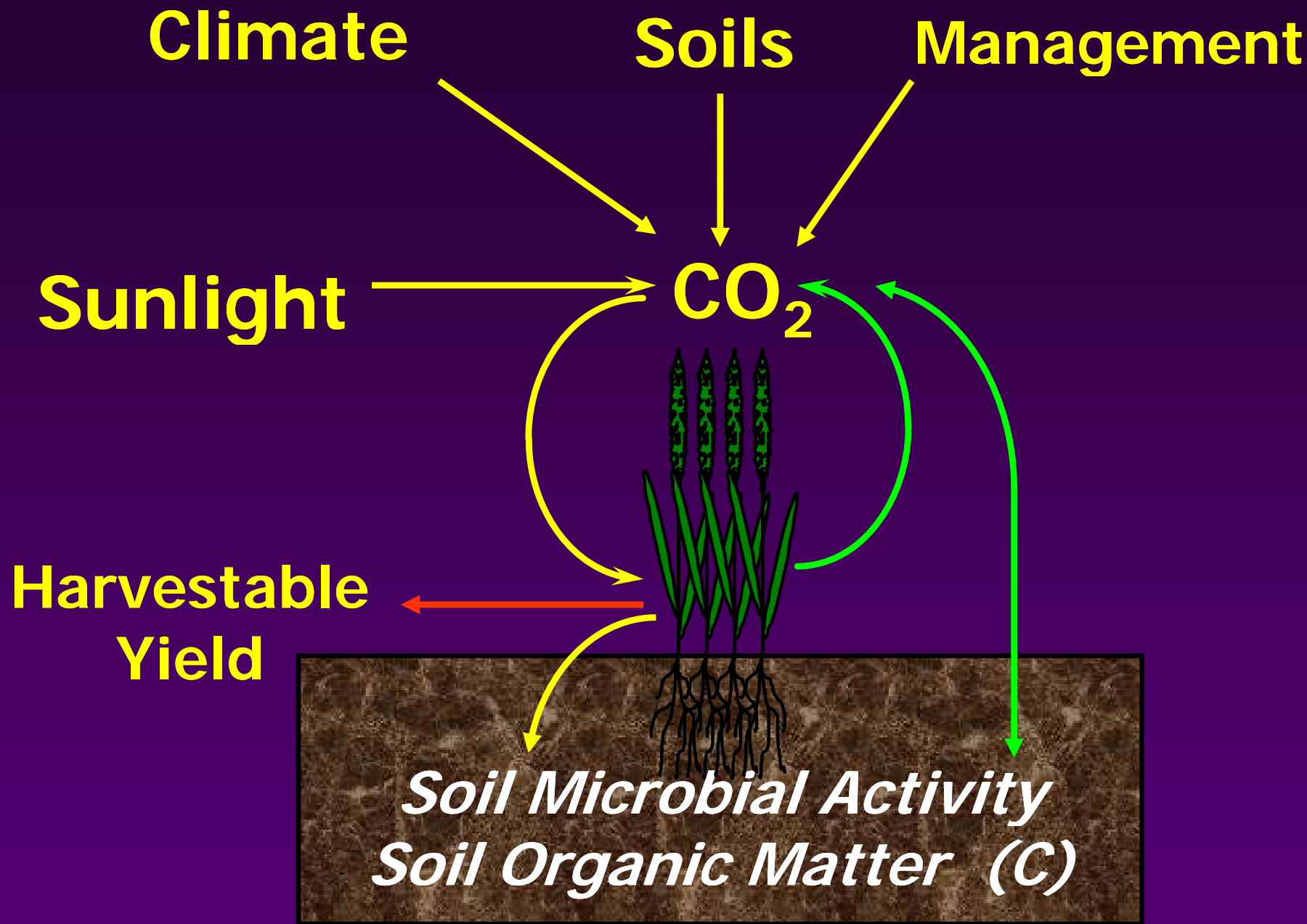


Agriculture

- A large proportion of the mitigation potential of agriculture (excluding bioenergy) arises from soil C sequestration, which has strong synergies with sustainable agriculture and generally reduces vulnerability to climate change.
- Agricultural practices collectively can make a significant contribution at low cost
 - By increasing soil carbon sinks,
 - By reducing GHG emissions,
 - By contributing biomass feedstocks for energy use

Global mitigation potential in agriculture

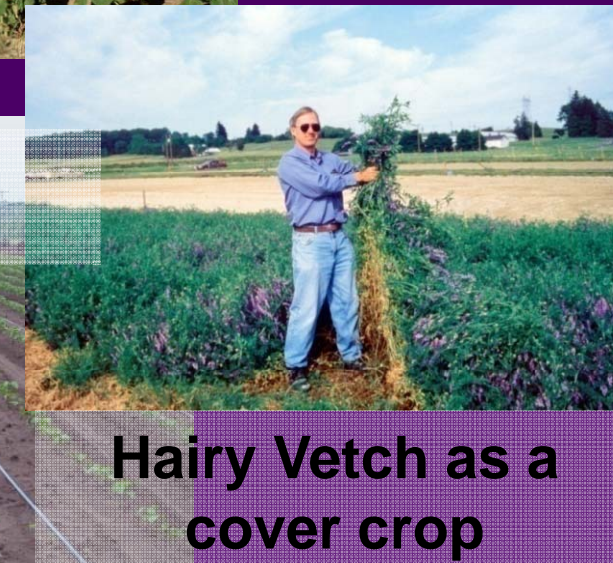




Many opportunities for GHG mitigation!

Cropland

- Reduced tillage
- Rotations
 - Reduced bare fallow
 - Increased intensity
- Cover crops
- Fertility management
 - Nitrogen use efficiency
- Water management
 - Irrigation management



Many opportunities for GHG mitigation!

Grasslands

- Grazing management
- Fire management
- Fertilization

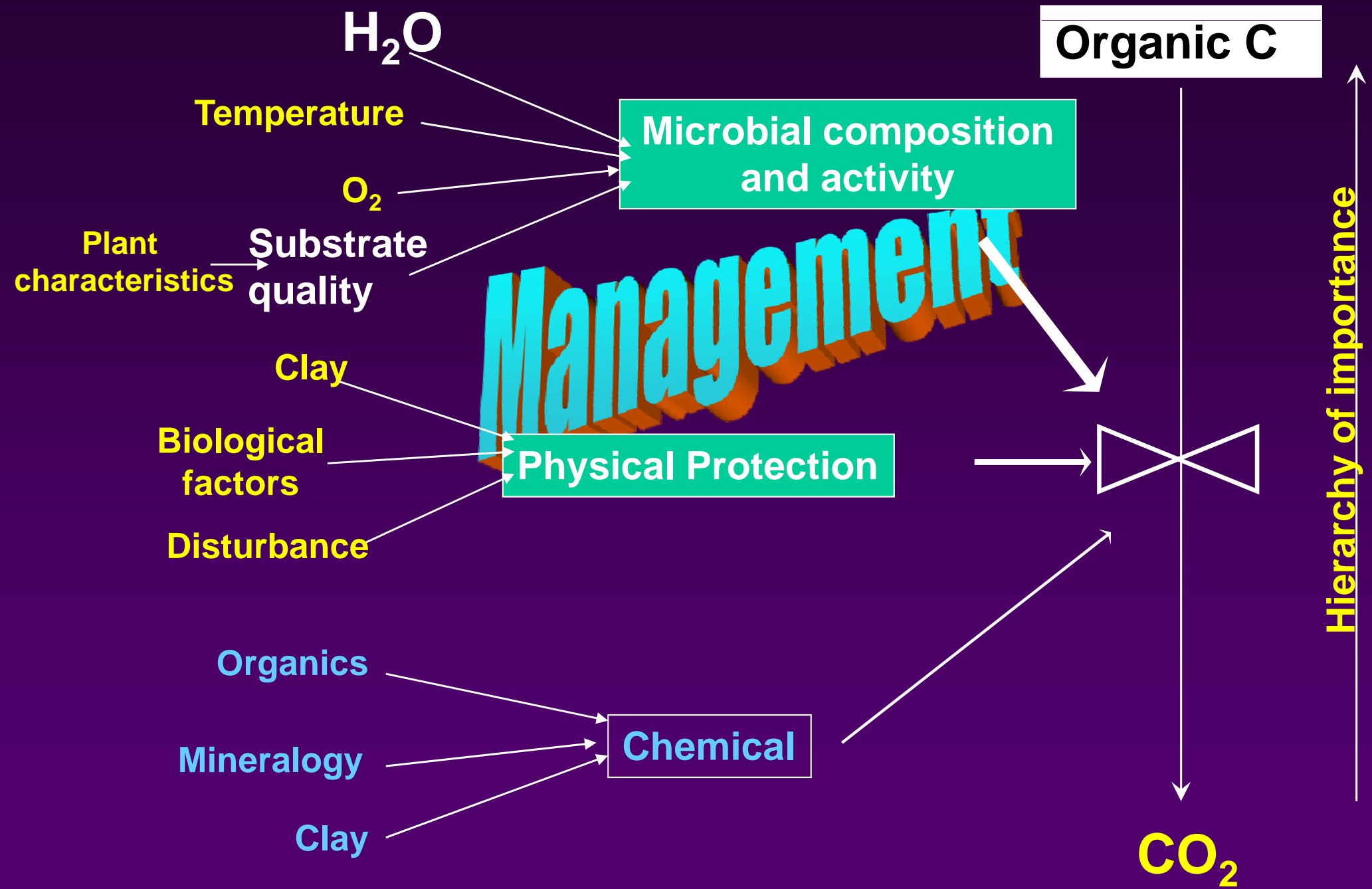


Managed Grazing



Controlled Burning

Conservation of Soil Carbon

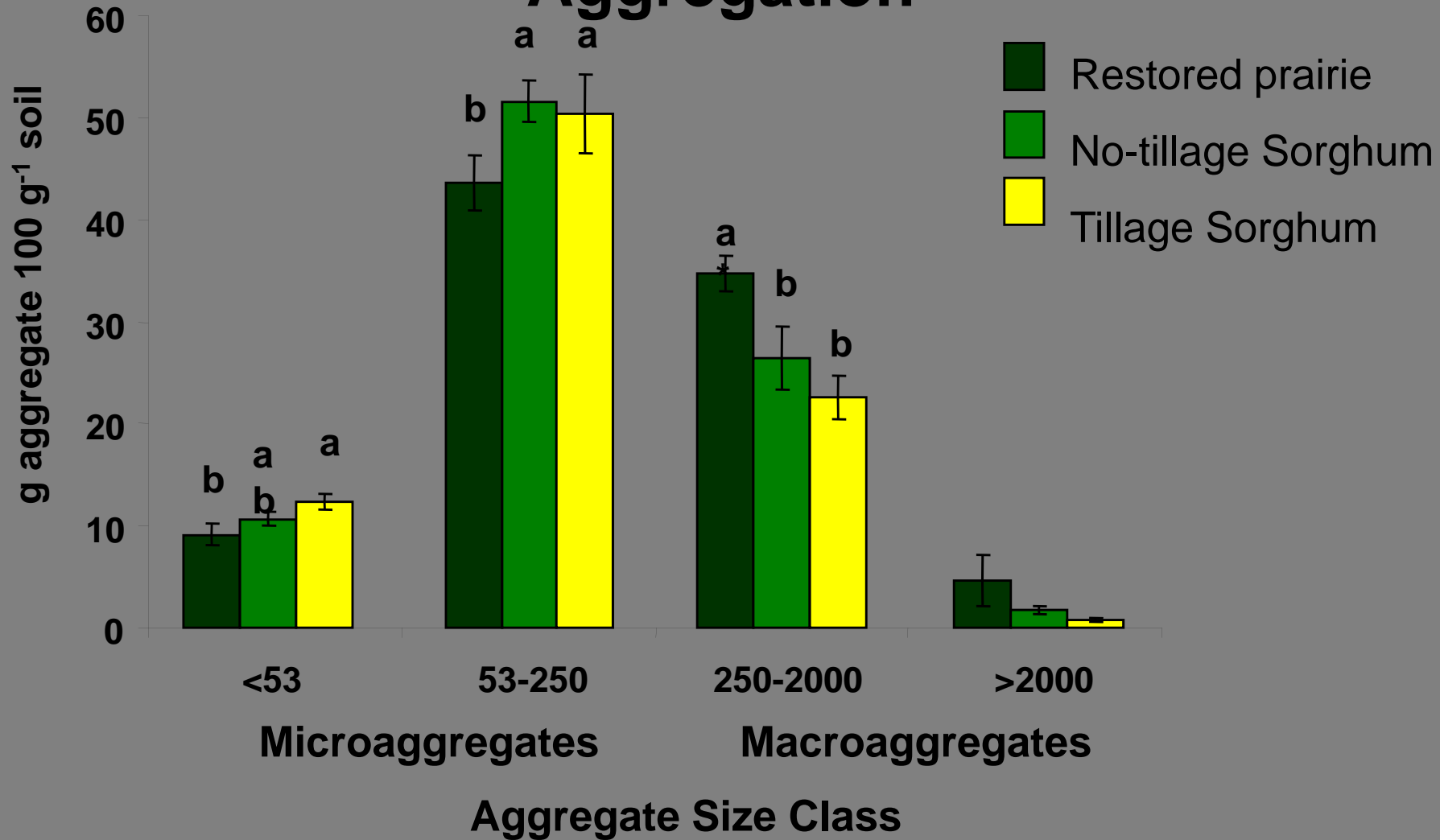


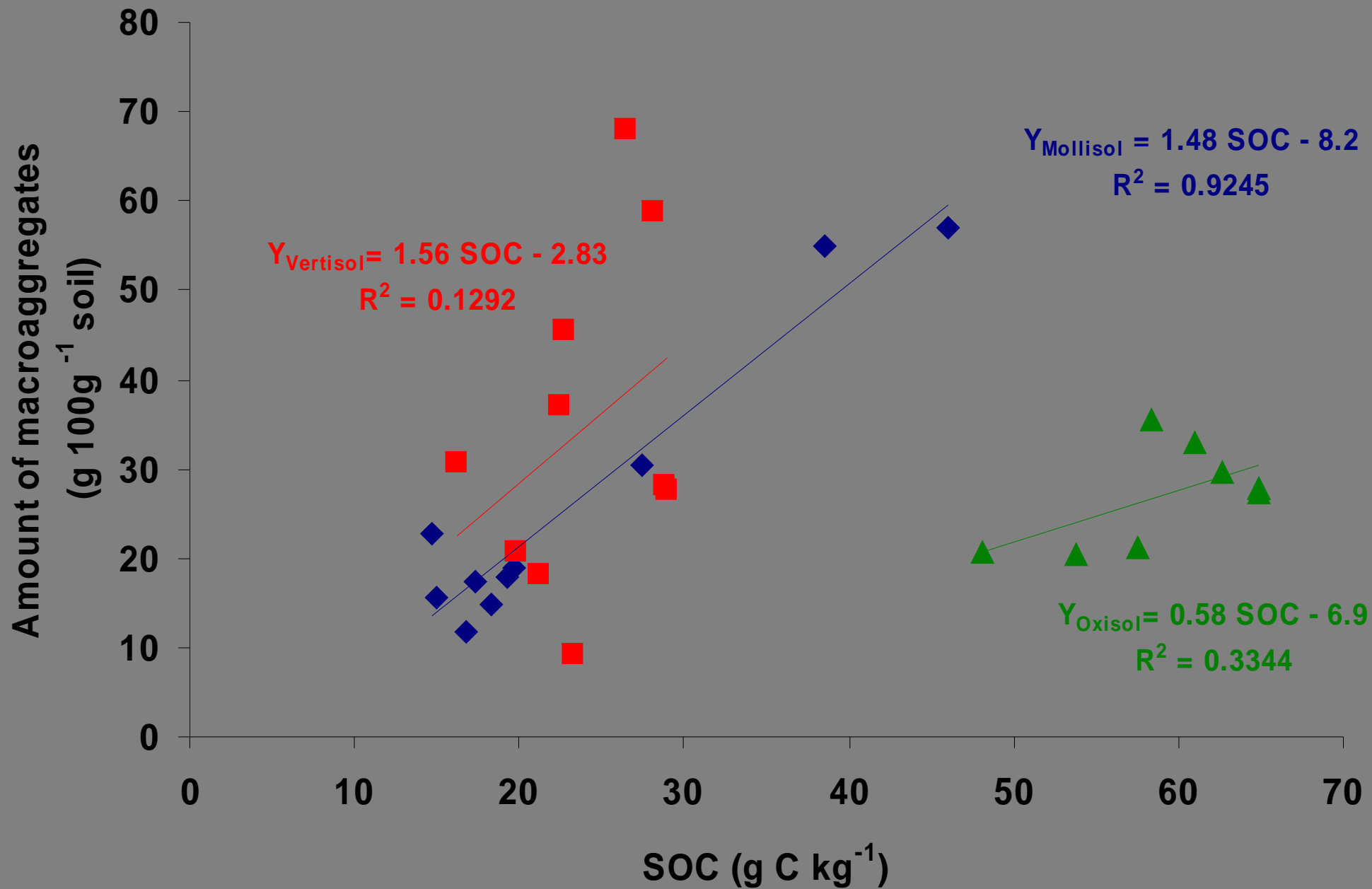
A close-up photograph of a hand holding a soil core. The soil is dark brown and contains numerous roots and organic matter, including sticks and twigs. A vertical green line with circular endpoints is drawn on the right side of the soil core, indicating a 5 cm depth. The background is a blurred field of green plants with small purple flowers.

No-till promotes fungal activity
5 cm

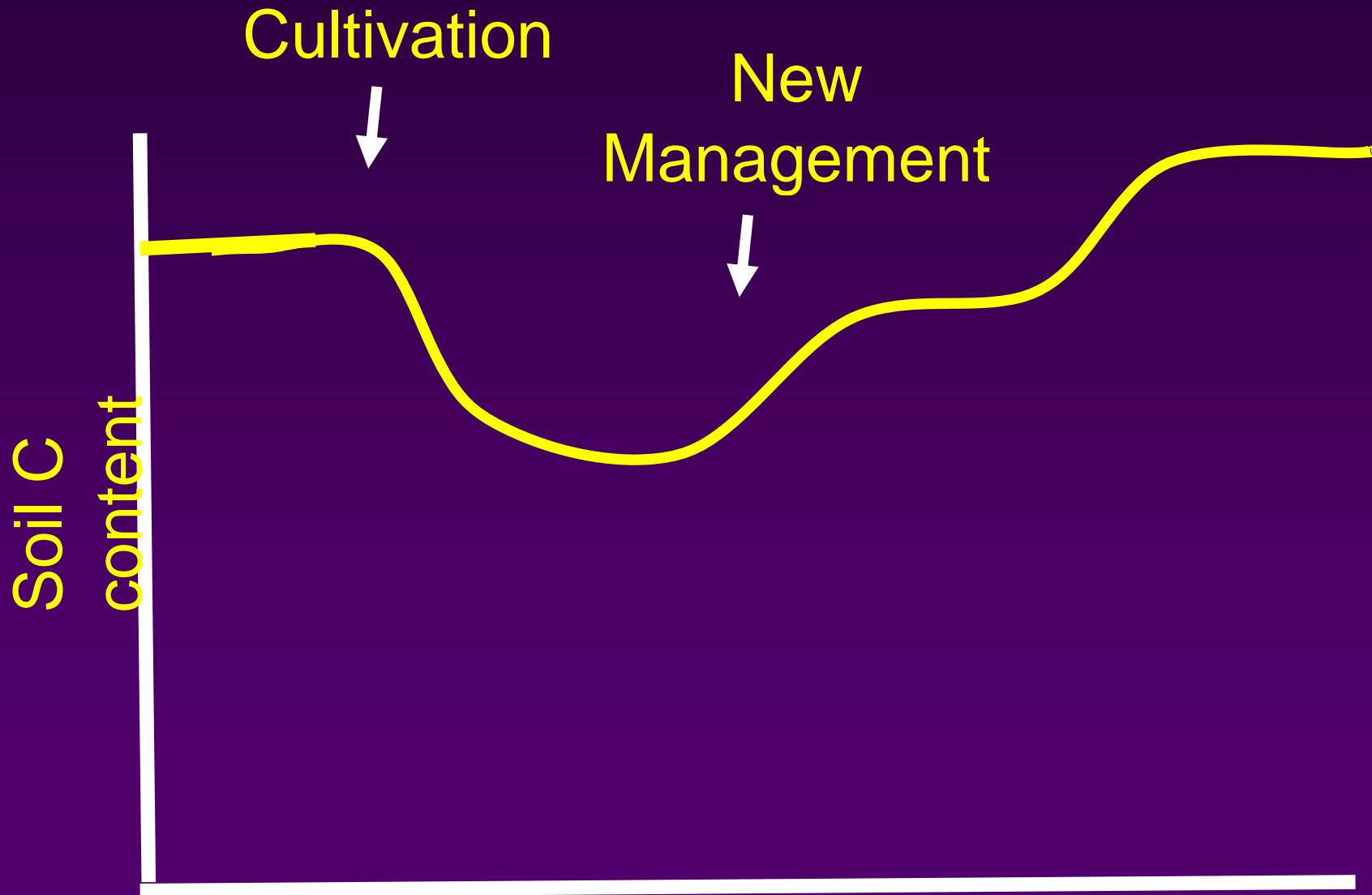
Fonte: Juca Sá

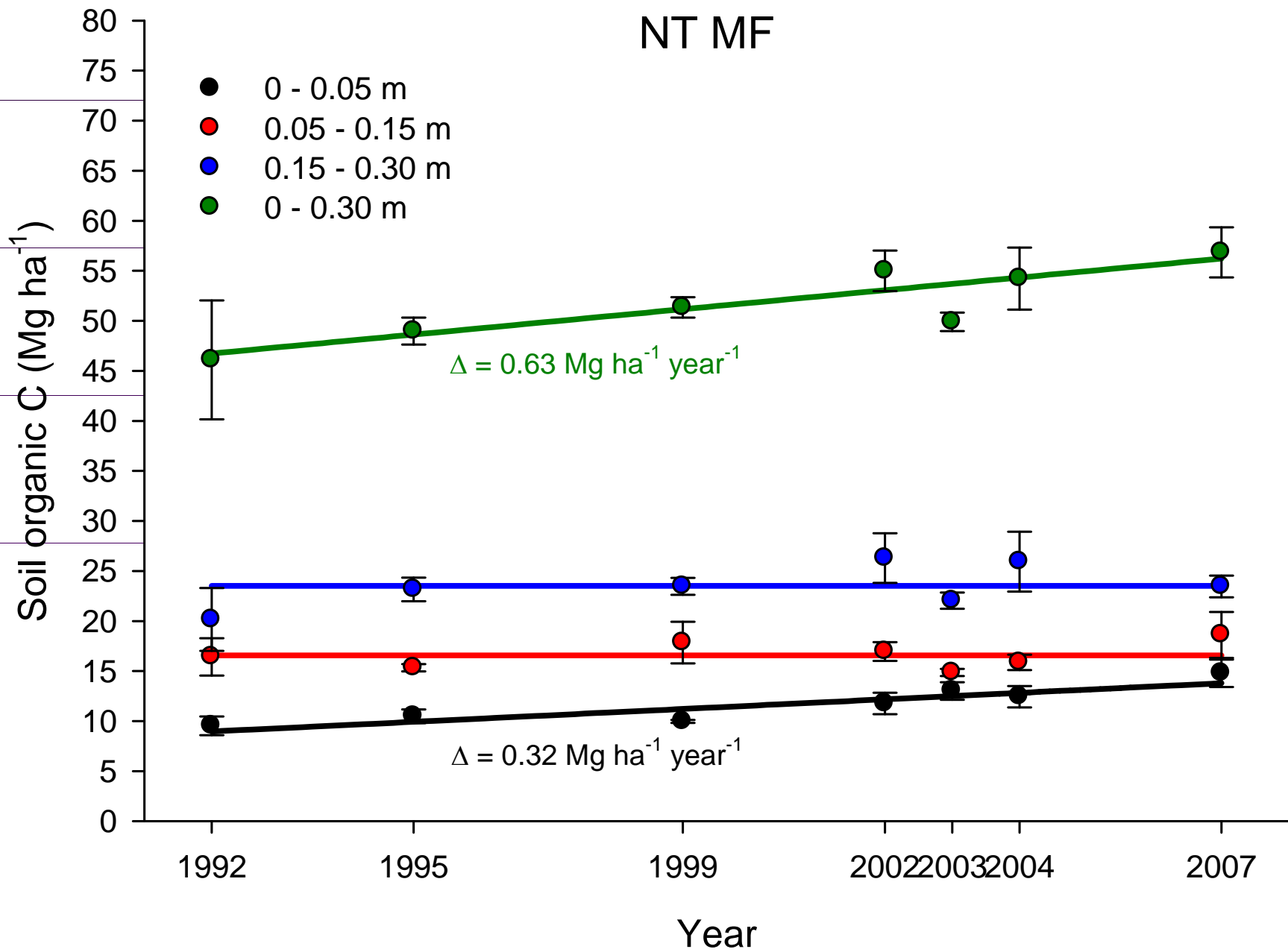
Soil Aggregation



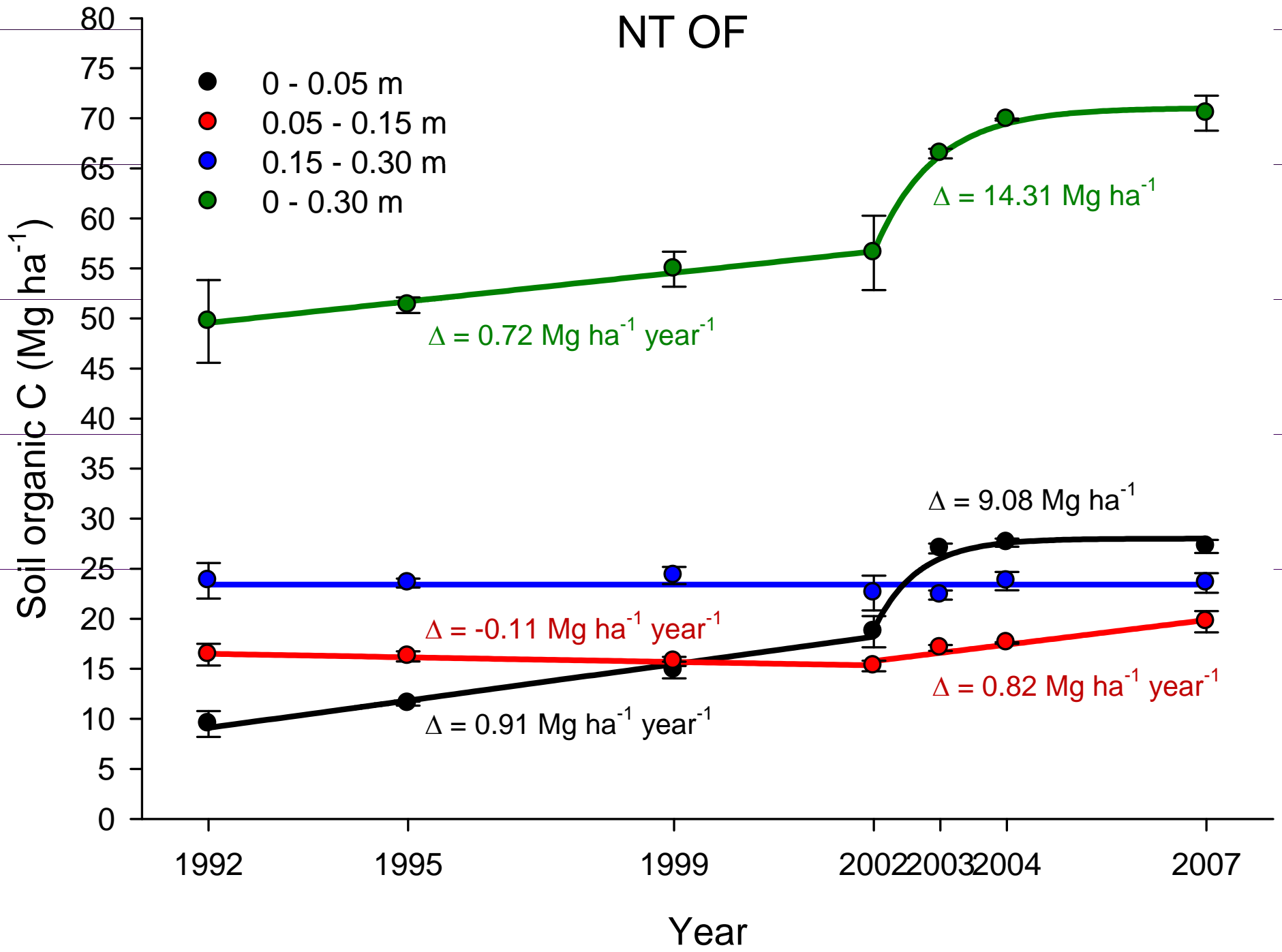


How long? How deep?
How much?



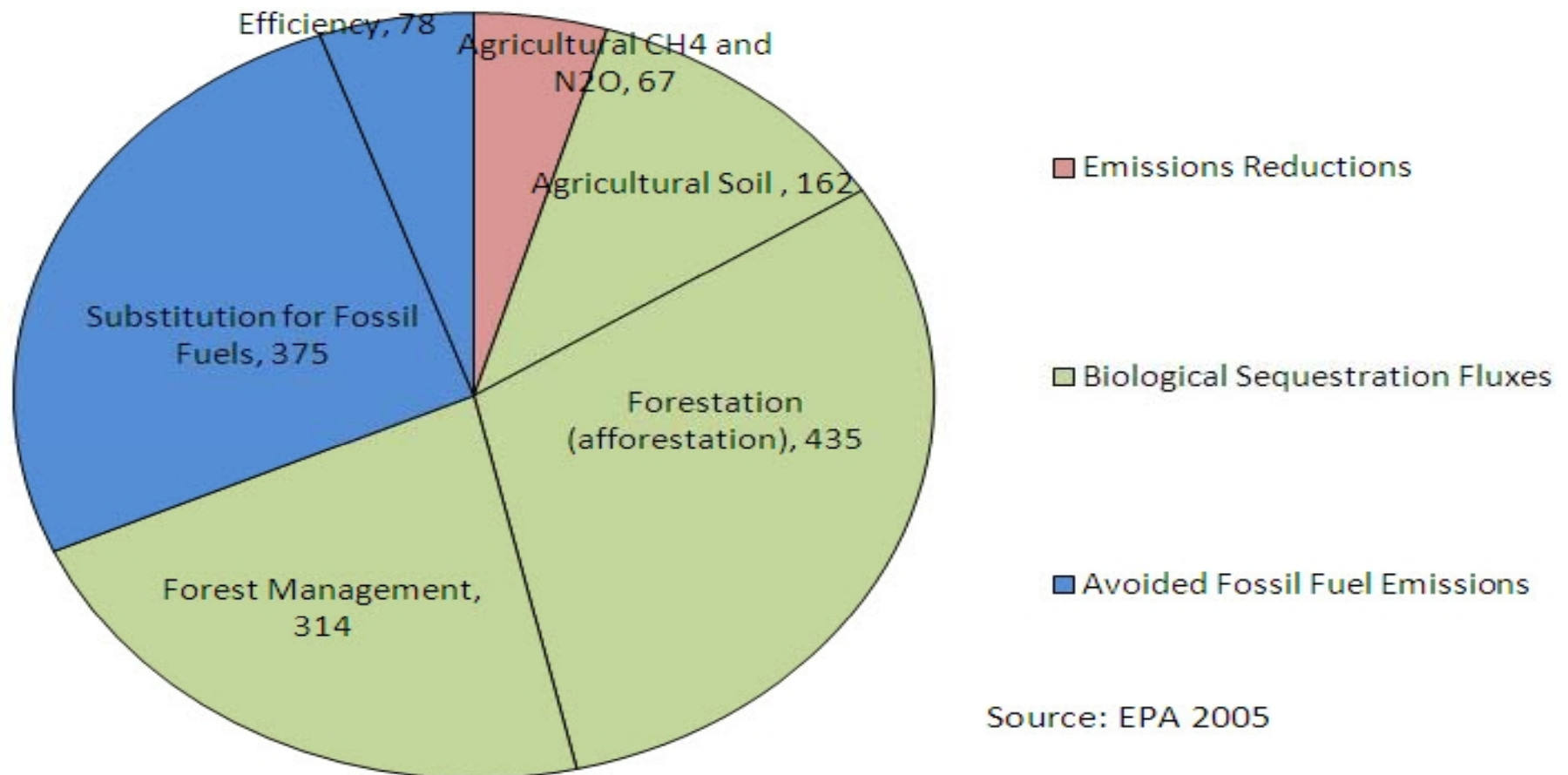


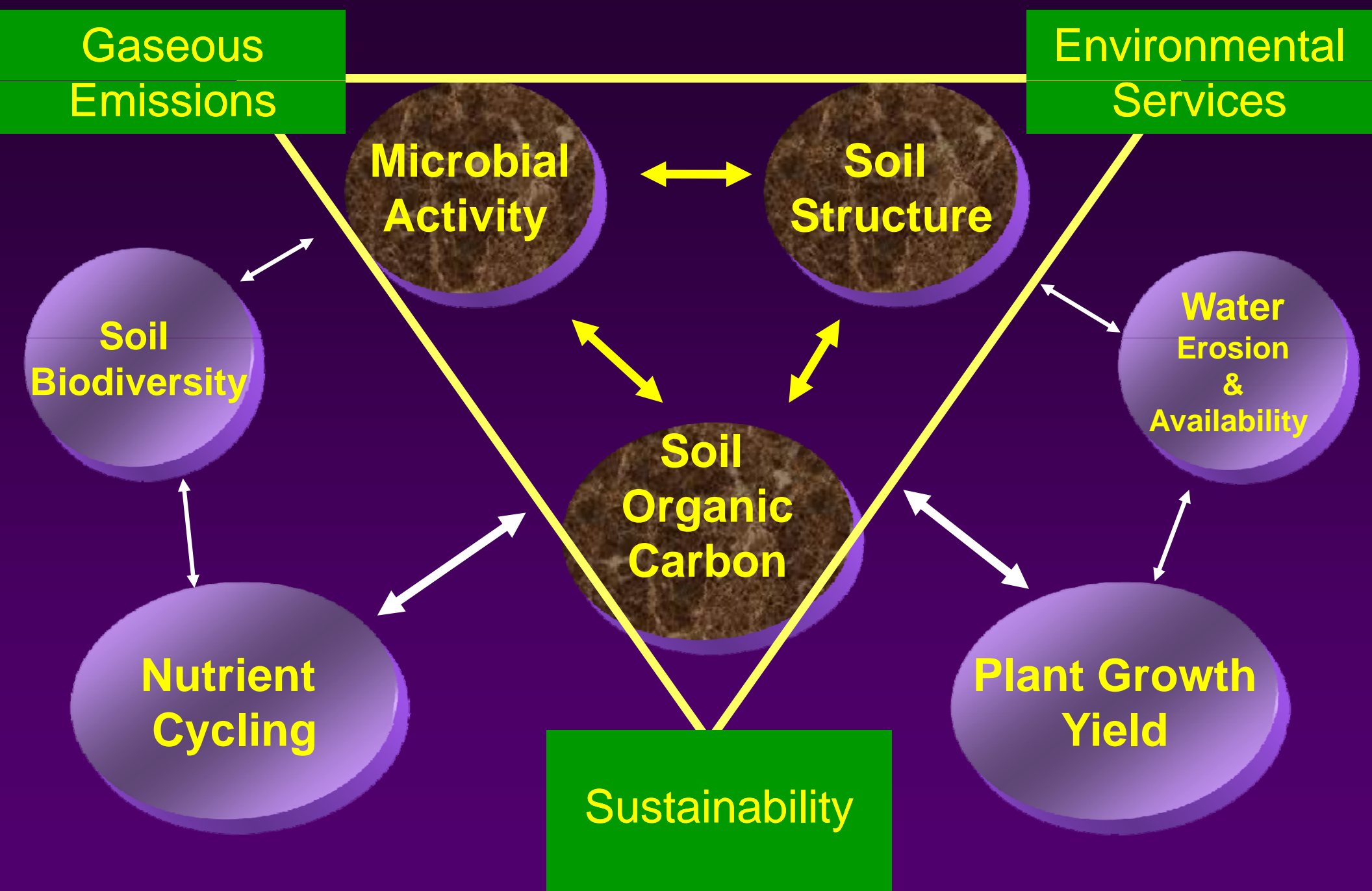
NT OF



Ag and forestry have the potential to offset 10 - 25 percent of total annual U.S. GHG emissions

National Agriculture and Forestry Mitigation Total 2010-2110, MMT CO₂e at \$30 per MT CO₂e (~20% of current total U.S. GHG emissions), Annualized Averages by Activity





Gaseous Emissions

Environmental Services

Microbial Activity

Soil Structure

Soil Biodiversity

Water Erosion & Availability

Soil Organic Carbon

Nutrient Cycling

Plant Growth Yield

Sustainability

Reduction Opportunities

■ Sequestration

- Conservation tillage and crop rotations
- Cover crops
- Grazing practices
- Forestation, reforestation, forest management

■ Avoided emissions

- Biofuel production
- Thermal bio-power and bio-heat
- Renewable electrical power

■ Emission reductions

- Manure management
- Fertilizer practices N₂O

Types of Agricultural & Forestry GHG Offset Transactions

- ***Outright Sale***

- Direct GHG emissions reductions –
N₂O, CH₄, CO₂
- Soil/Biomass Carbon –
permanent commitment

- ***Term-Limited Lease***

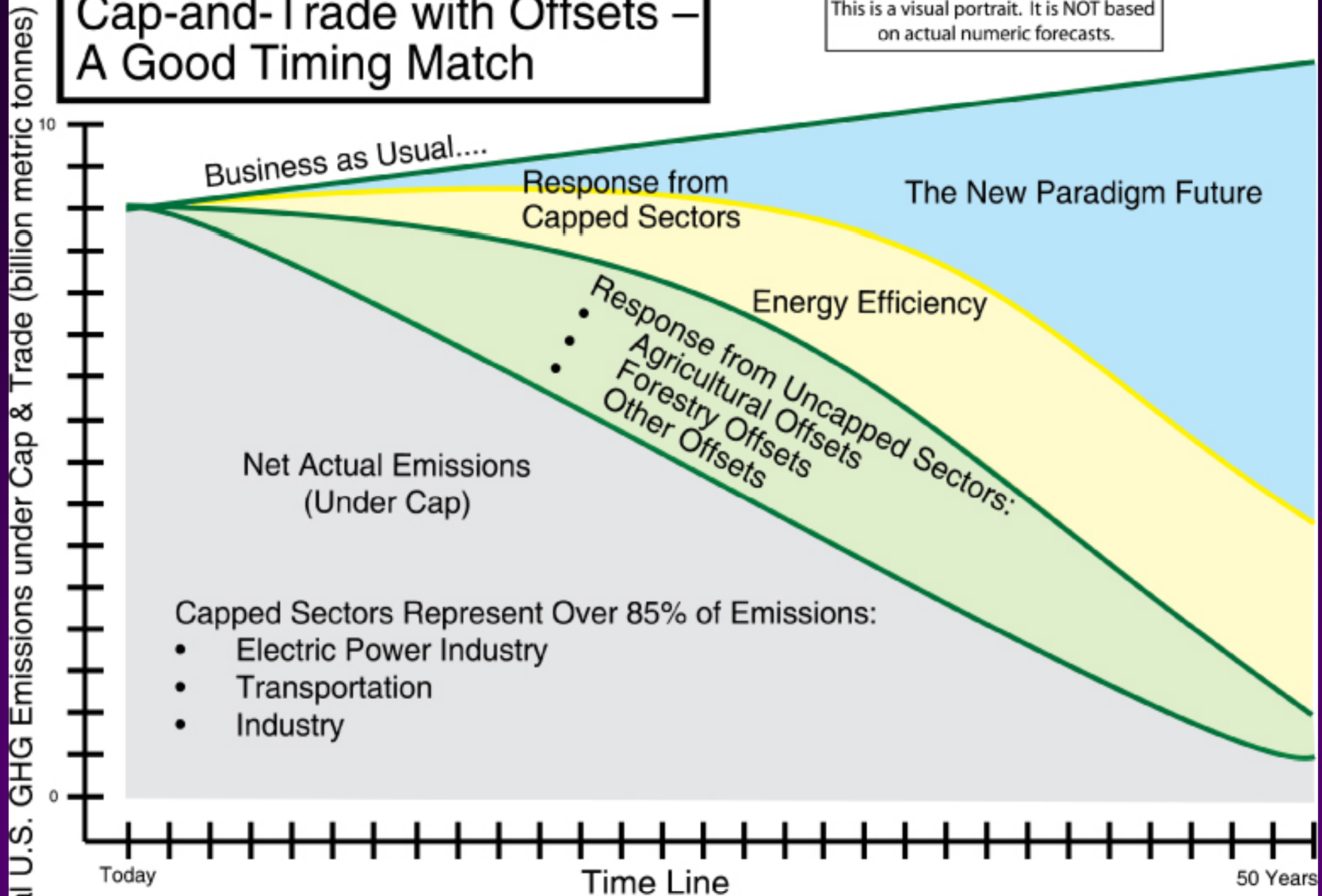
- Soil carbon storage
- Biomass storage

Offsets Are Critical for Cap & Trade

- Induces Change in Uncapped Sectors
- Reduces Program Costs
- Produces Large Volumes Earlier
- Fills the Timing Gap; Bridges to the New Energy Future

Cap-and-Trade with Offsets – A Good Timing Match

This is a visual portrait. It is NOT based on actual numeric forecasts.



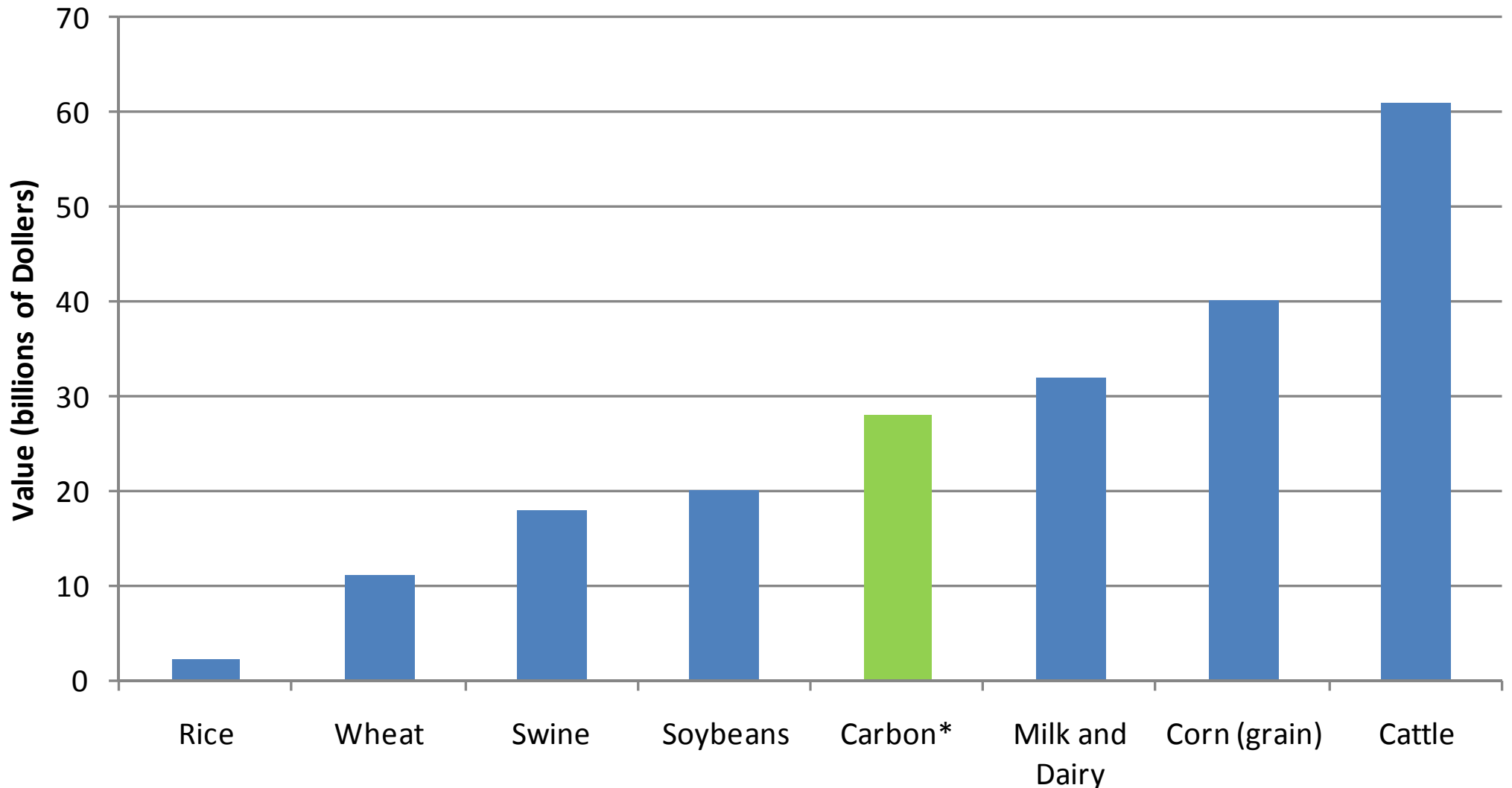
Farm and forestry offset services – UNDER A PROPERLY DESIGNED PROGRAM - offer a great advantage to the capped sectors under cap-and-trade. Key benefits include: Immediate delivery of low-cost reductions to capped sectors; low-cost abatement opportunities that will reduce energy costs to American households; a growing volume of reductions as carbon prices rise over time in response to a declining cap; a saturation of the biological sequestration sources of emissions reductions at a time when the capped sectors have had ample opportunity to overcome capital turnover times, and the requisite technological solution development demanded by the fundamental paradigm shift to a low-carbon economy.

Examples of feasibility and pilot projects on soil carbon sequestration

Region	Land Use	Land management change
Saskatchewan, Canada	Cropland	Direct seeding / cropping intensification
Pacific Northwest, USA	Cropland	Direct seeding / cropping intensification
Midwest Iowa, Kansas	Cropland Grass planting	No-till New grass plantings
Oaxaca, Mexico	Crop / natural fallow secondary forest	Fruit tree intercrops with annual crops / Conservation tillage
Pampas, Argentina	Cropland	Direct seeding
Kazakhstan	Cropland	Agriculture to grassland

Carbon as a Revenue Crop

Value of Agricultural Products



Data source: 2007 Census of Agriculture, USDA NASS February 2009;

*Carbon estimate based on 25x25 derivation of 20% x 7 billion tons/yr x \$20 ton

Primary Challenges

- Costs
 - Changes in operating practices
 - Tracking and selling offsets
 - Increased input cost (esp. fuel and fertilizer)
- Getting the correct enabling policy in place
- Development of viable markets
- Informing ag and forest sectors of opportunities, challenges, alternatives and consequences
- Shaping our own destiny

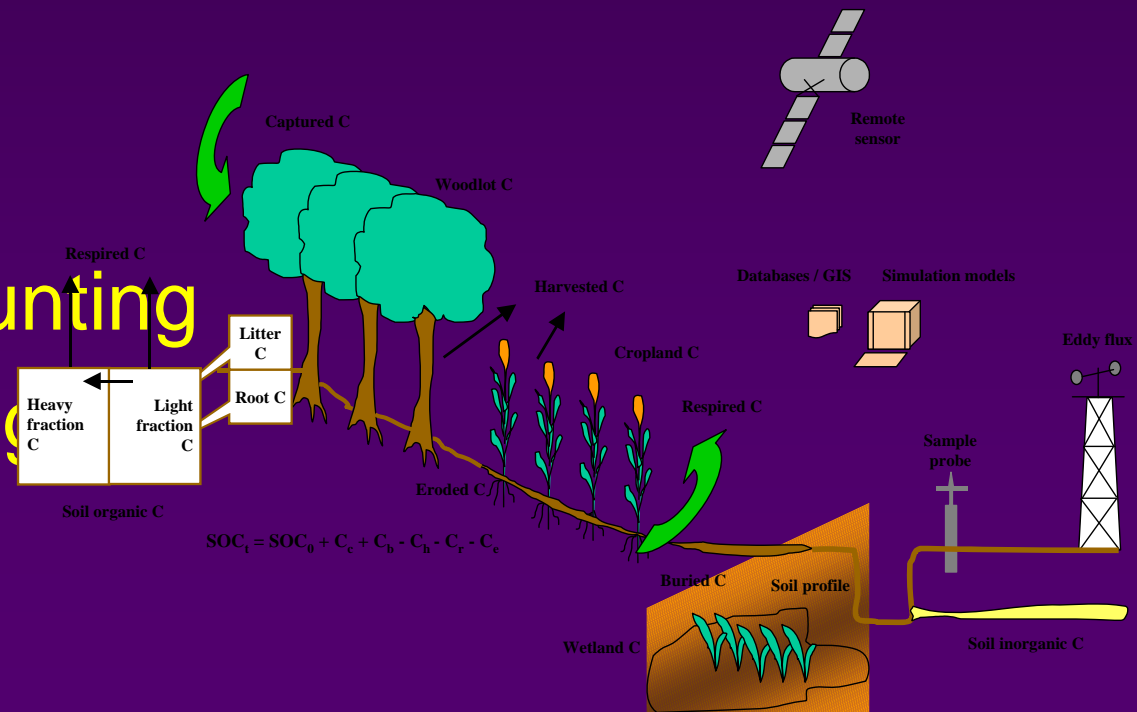
Measurement, Monitoring and Verification

- Detecting soil C changes
 - Difficult on short time scales
 - Amount of change small compared to total C

- Methods for detecting and projecting soil C changes (Post et al. 2001)

- Direct methods
 - Field measurements
- Indirect methods
 - Accounting

- Stratified accounting
- Remote sensing
- Models



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Production Costs

Iowa State

- Roughly a 1.5% increase for corn and soybean farmers by 2020

University of Missouri (FAPRI)

- Dryland corn 3.2% increase by 2020
- Irrigated corn 3.5% increase by 2020
- Soybeans 1.6% by 2020

Primary Challenges

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Policy

- State and Regional Policy
 - California
 - Northeast Region
 - 34 State Climate Action Registry (Kansas included)
 - Western Governors Association
 - Midwest Governors Association
- National Policy
 - Farm Bill
 - Many programs tie to offsets
 - CSP, EQIP
 - Voluntary Registry
 - Climate Change Legislation (will ag be included)
 - Cap and Trade
 - Carbon Tax
- International
 - Kyoto (EU has a trading platform)
 - Partnerships

Waxman-Markey Bill

- Sets a cap on GHG emissions
 - 17% reduction by 2020
 - 83% reduction by 2050
- Allows 2 billion tons of offsets
 - Split equally between domestic and international sources
- Allocates ~86% of allowances
 - Rural Cooperatives get a portion

Peterson Amendments

- Makes USDA responsible for managing the agricultural offset program
- Further specifies how the offset program will operate
- Provides protection for "early actors"
- Incorporates a list of practices that will be eligible for inclusion in the offset program
- Commodity Futures Trading Commission regulates the trading of derivatives for emission allowances, offset credits and renewable electricity credits

Conclusions: Mitigation

- Agriculture has a significant role to play in climate mitigation
- Agriculture is cost competitive with mitigation options in other sectors
- Bio-energy crops and improved energy efficiency in agriculture can contribute to further climate mitigation
- Agricultural mitigation should be part of a portfolio of mitigation measures to reduce emissions / increase sinks while new, low carbon energy technologies are developed.

BIODIVERSITY CREDITS

Conservation organizations are leasing development rights from the owners of undisturbed forests and other habitats that host threatened endemic species and fast-vanishing ecosystems.



CO₂ OFFSET CREDITS

When landowners plant new forests and promise never to cut or burn the trees, they can receive carbon dioxide offset credits that industries will buy to help them comply with restrictions on greenhouse gas emissions.



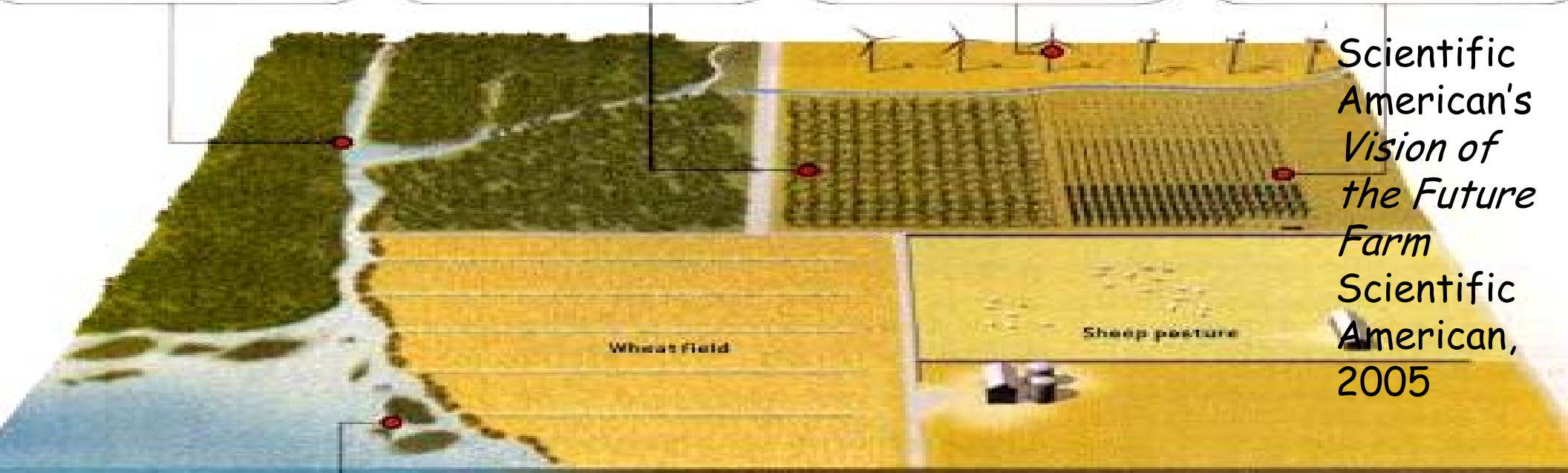
RENEWABLE ELECTRICITY

Wind farms generate nonpolluting electricity that commands premium prices in deregulated power markets. The turbines can also garner tax credits that subsidize their capital and operating costs.



CERTIFIED SUSTAINABLE TIMBER

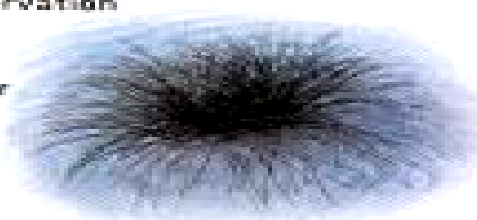
Sustainably harvested timber is now one of numerous "eco-labeled" products that are certified as ecologically sound and sold at a premium in specialty markets.



Scientific American's Vision of the Future Farm
Scientific American, 2005

WATER CREDITS

Careful management of water and wetlands is economically valuable for many reasons. Urban water authorities purchase water filtration credits to protect the quality of their watersheds; wetland owners can also receive compensation from government agencies for flood-control services, from conservation organizations for the preservation of migratory waterfowl breeding areas, and from agricultural cooperatives for the prevention of soil salinity increases caused by overdrawn groundwater aquifers.



COMMODITY	PERCENT OF FARM'S INCOME	CUSTOMER
Biodiversity credits	5	Conservation trust
CO ₂ offset credits	10	Steelmaker
Renewable electricity	15	Power market
Certified sustainable timber	20	Specialty market
Water credits	20	Urban water market
Wheat	15	World market
Wool	15	World market

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