

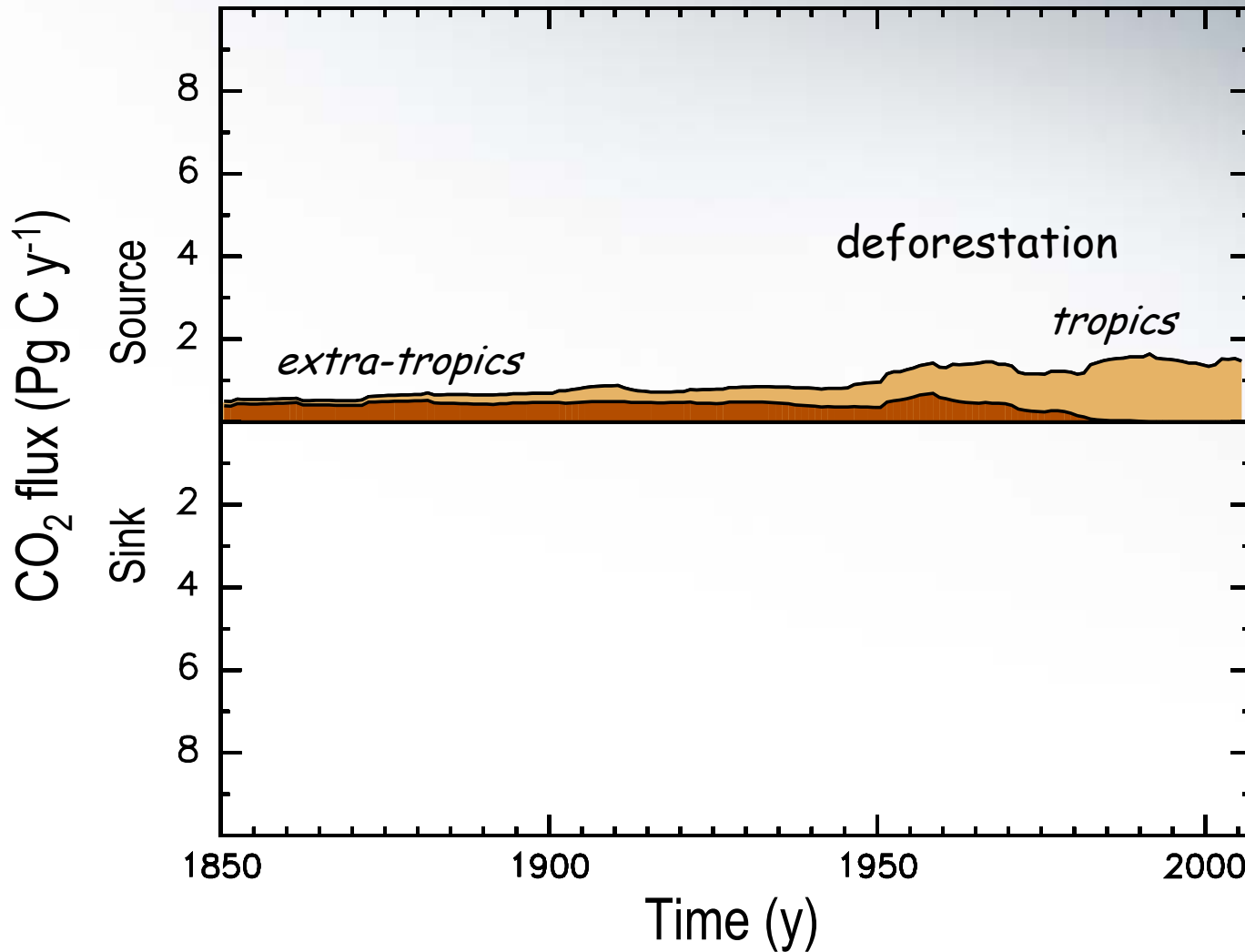
Greenhouse gases and agriculture: an introduction to the processes and tools to quantify them

Richard T. Conant

Natural Resource Ecology Laboratory
Colorado State University



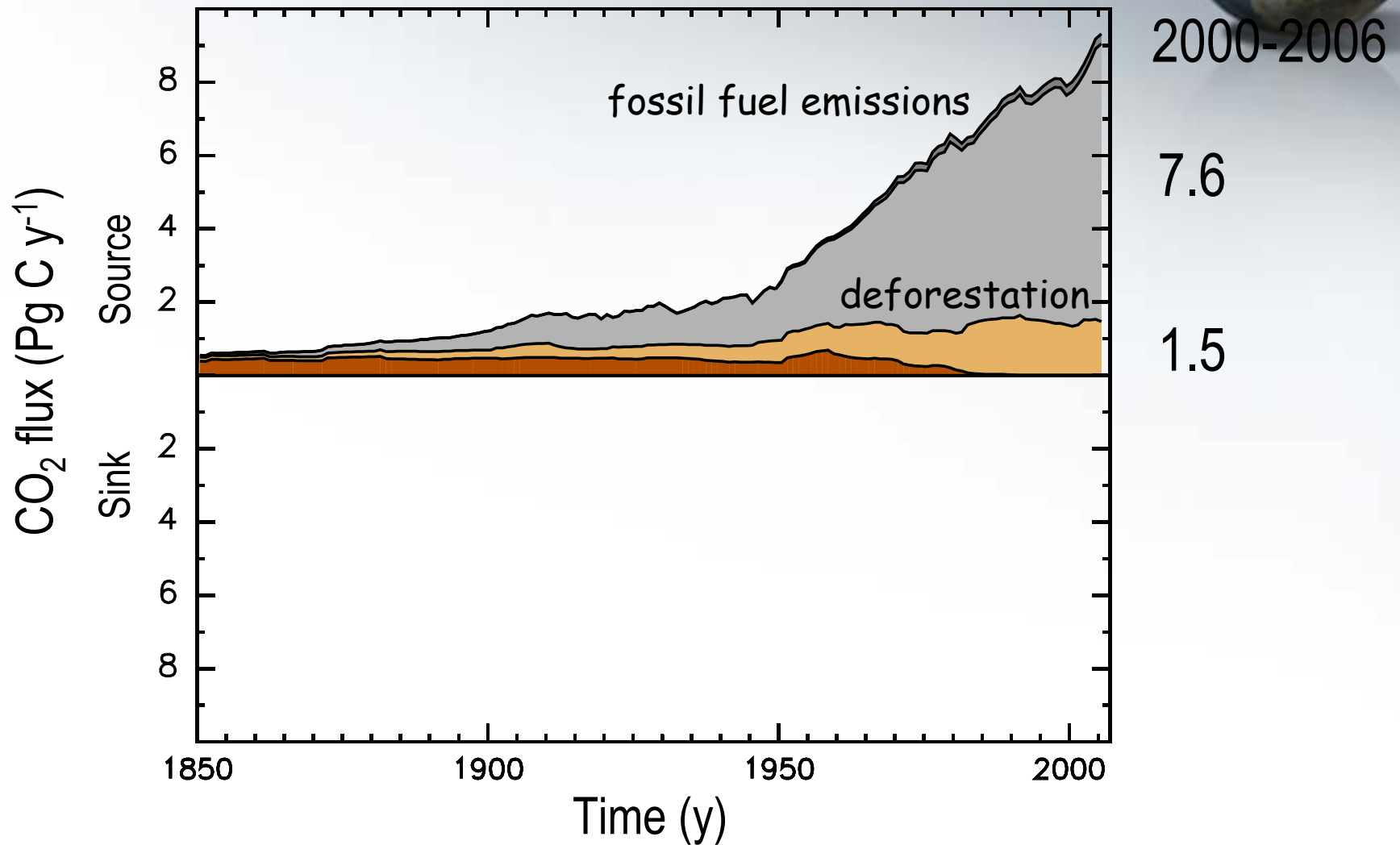
Perturbation of Global Carbon Budget (1850-2006)



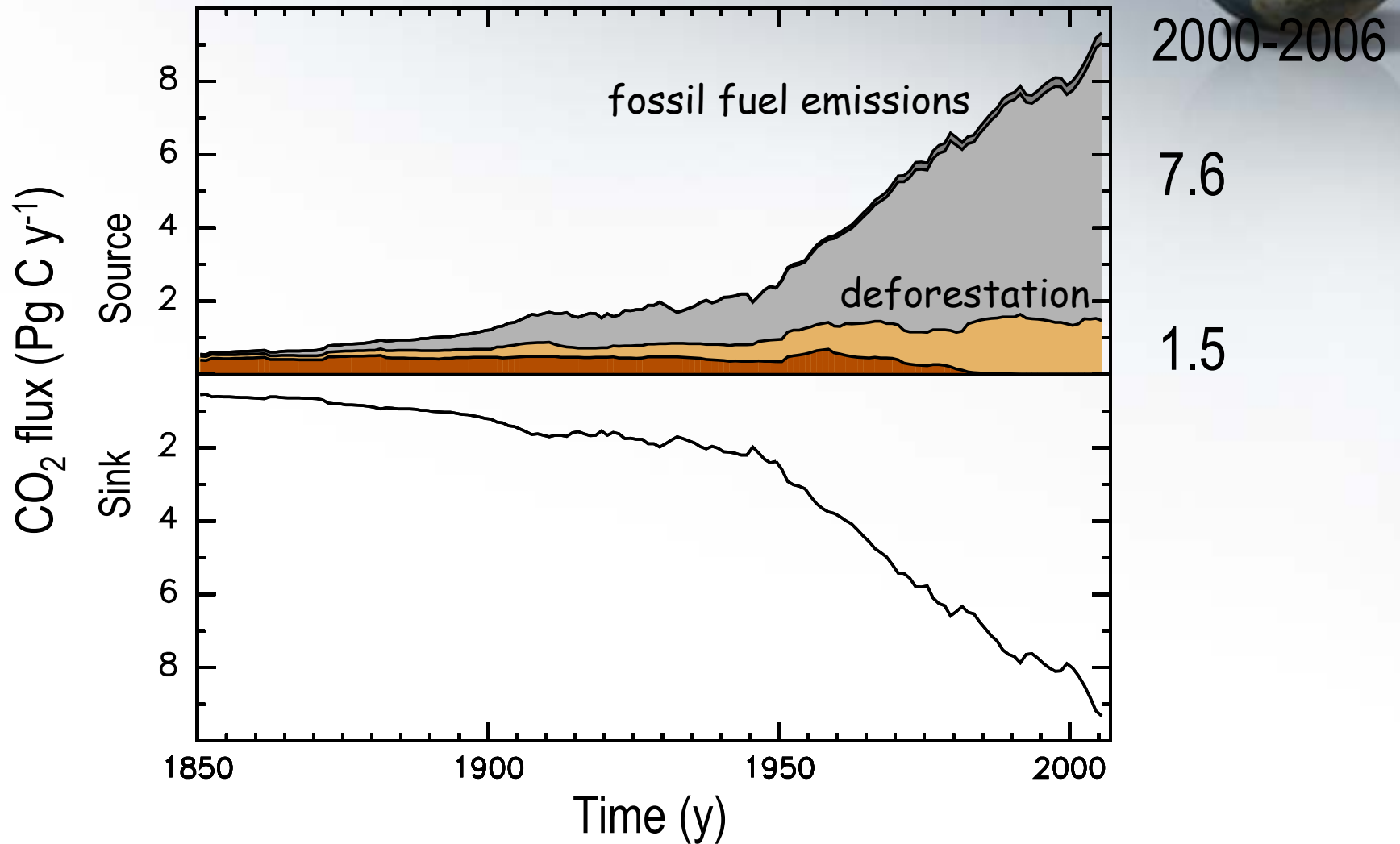
2000-2006

1.5

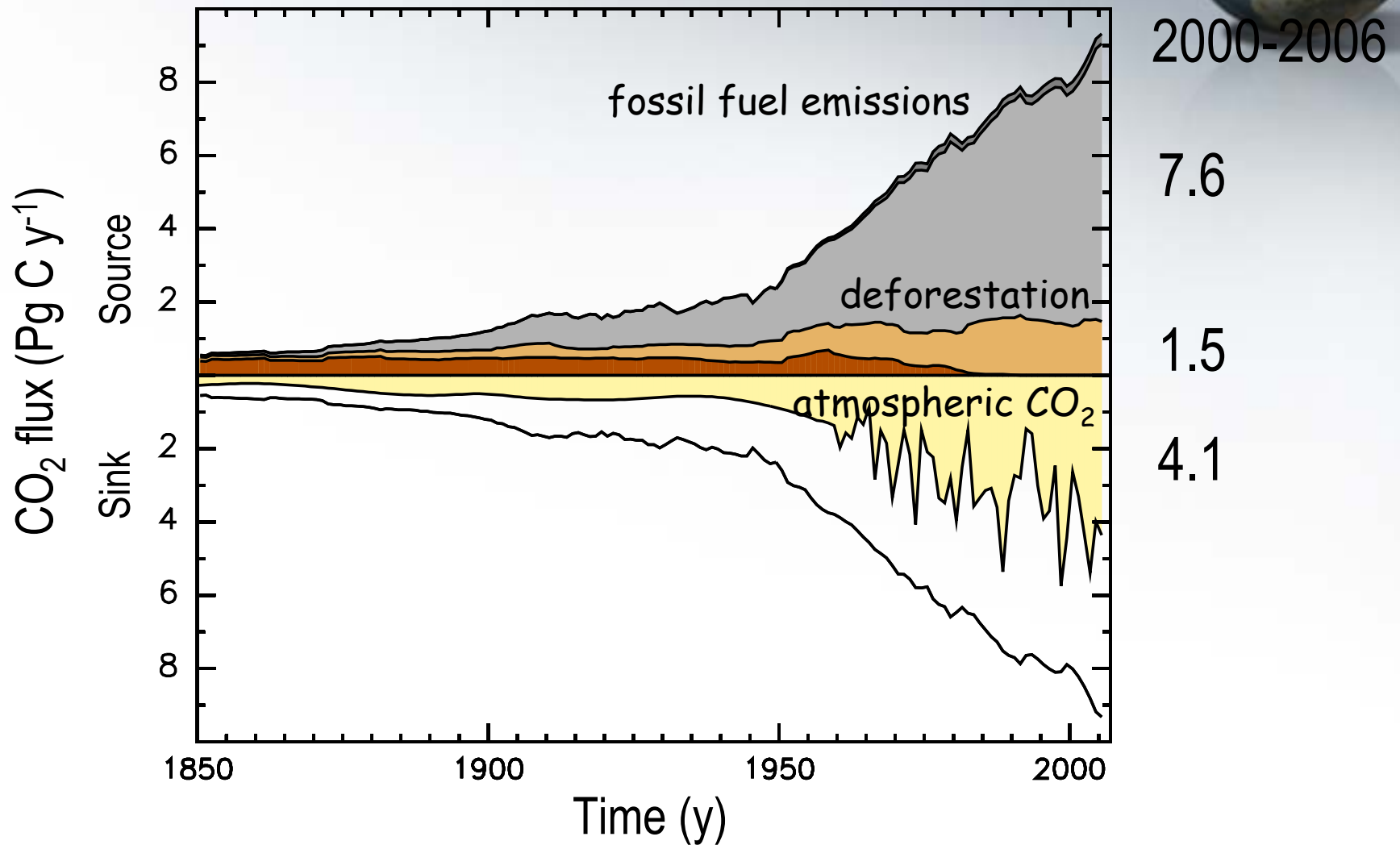
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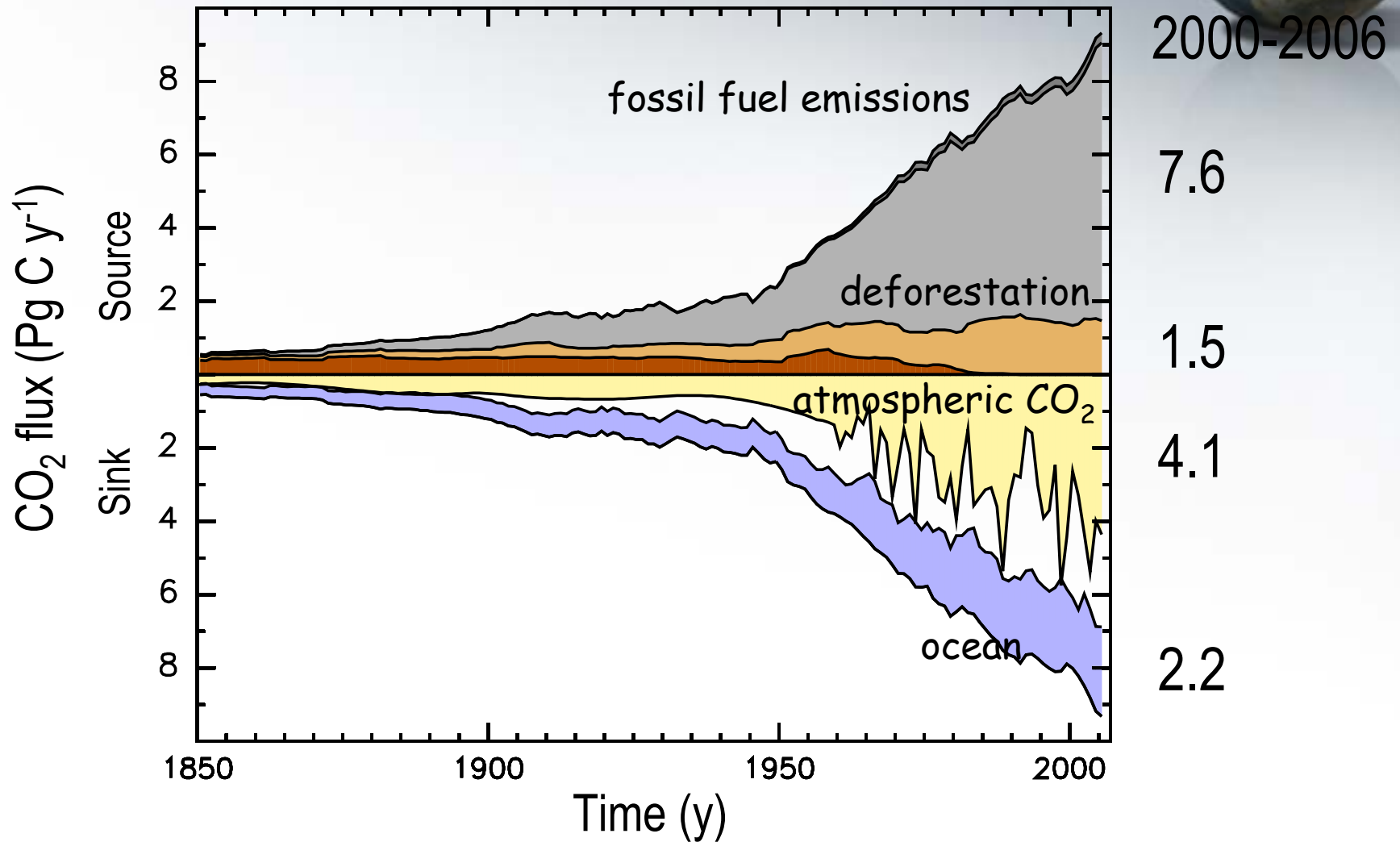
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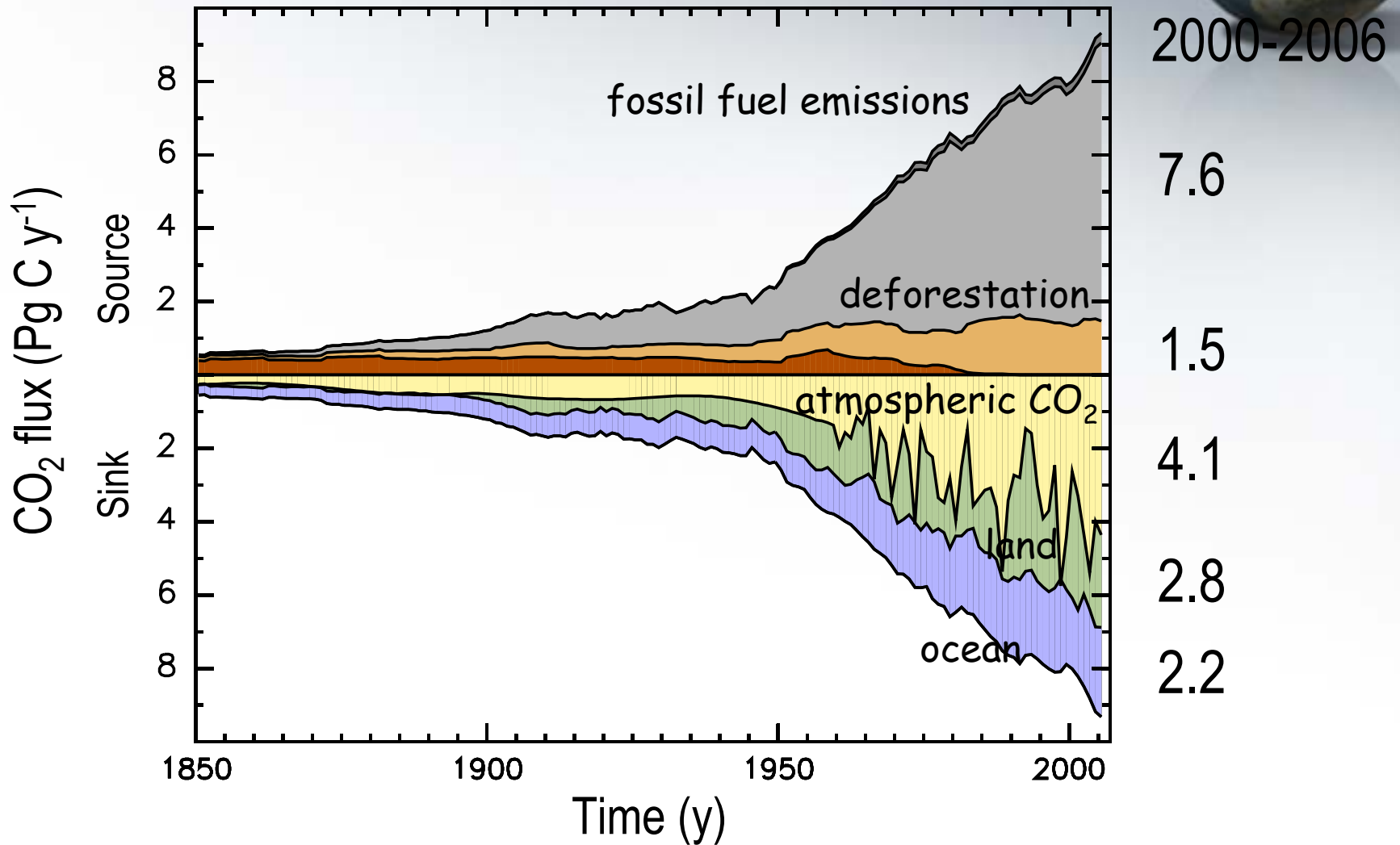
Perturbation of Global Carbon Budget (1850-2006)



Perturbation of Global Carbon Budget (1850-2006)



Perturbation of Global Carbon Budget (1850-2006)



Partition of Anthropogenic Carbon Emissions into Sinks

[2000-2006]

45% of all CO₂ emissions accumulated in the atmosphere



Atmosphere

The Airborne Fraction

The fraction of the annual anthropogenic emissions that remains in the atmosphere

55% were removed by natural sinks

Ocean removes _ 24%



Land removes _ 30%



Main points



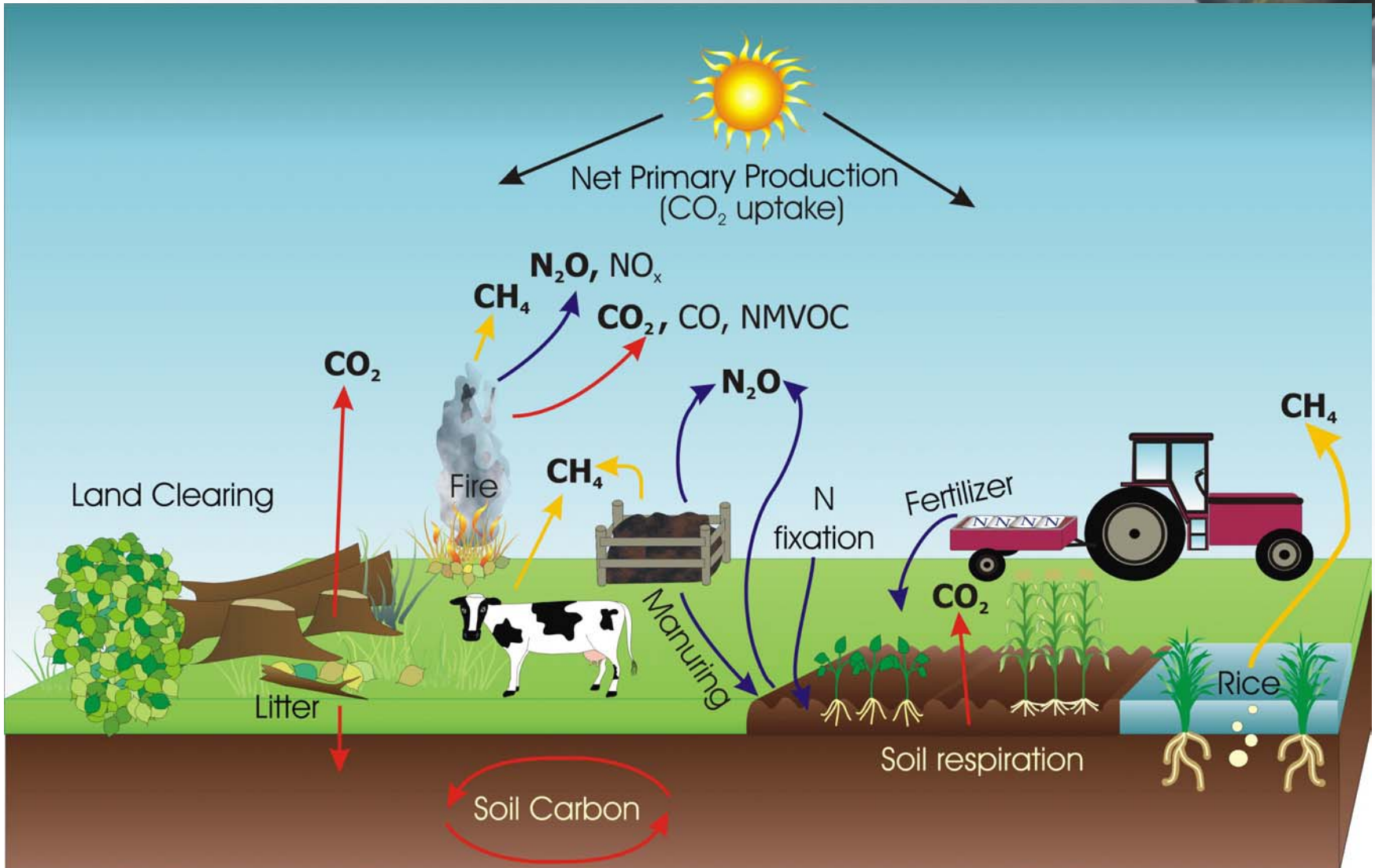
- 1) Agriculture is a significant emitter of GHGs
- 2) Agriculture can play a major role in mitigation – reducing total US emissions by 5-14%.
- 3) Action on GHG emission reduction is imminent.
- 4) Methods and tools already exist to quantify GHG emission reductions and soil C sequestration.

Main points



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Agricultural sources and sinks of greenhouse gases

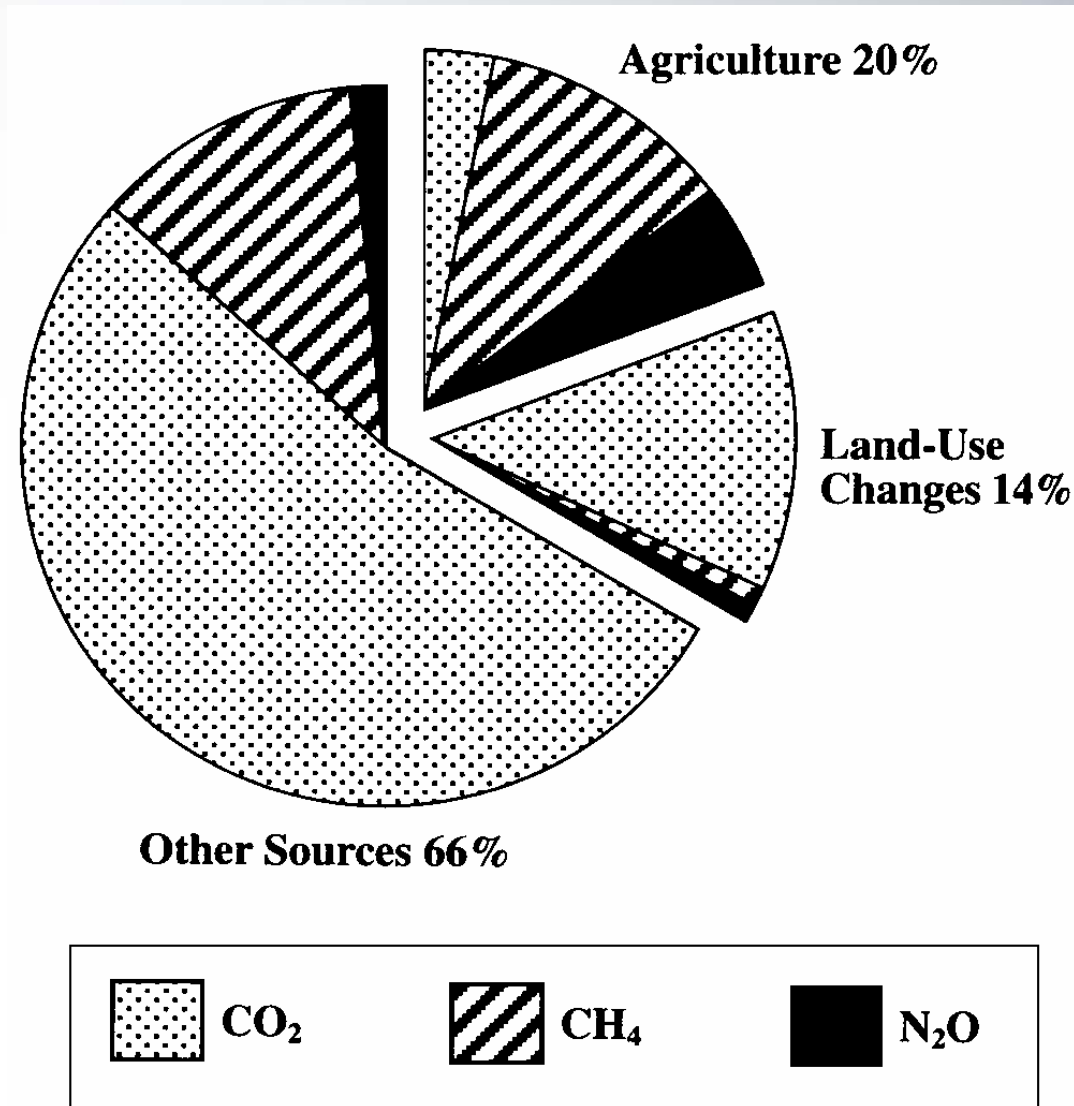


Global GHG balances



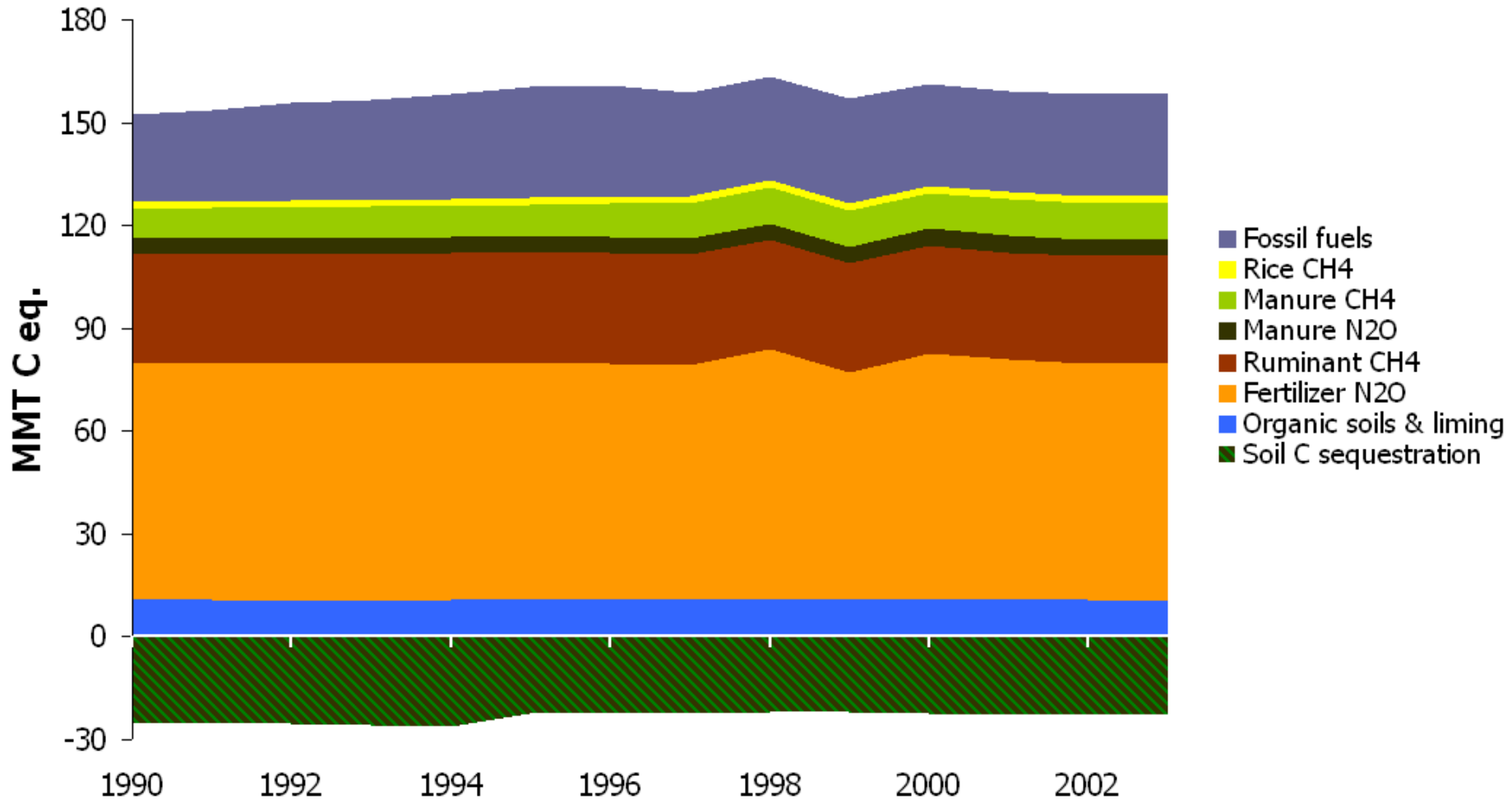
- CO₂, CH₄ and N₂O are the main gases of concern to agriculture and forestry.
- Global C budget (1990's)
 - Net land-atmosphere sink: -1.4 ± 0.3 Pg C/yr, but uncertainty high for land use emissions (0.6 to 2.5 Pg C/yr) vs terrestrial sink (-2 to -3.9 Pg C/yr)
- Global N₂O budget
 - $\pm 30\%$ uncertainty in global totals for sources/sinks
 - 75% of total emissions are from terrestrial ecosystems (ca. 50% from agriculture)
- Global CH₄ budget
 - $\pm 50\%$ uncertainty in global totals for sources/sinks
 - 60-70% from terrestrial ecosystems (ca. 35% from agriculture)

Emissions impact adjusted for radiative forcing (GWP) - global



Source: Cole et al. 1996

Agriculture accounts for ~ 7% of total US emissions



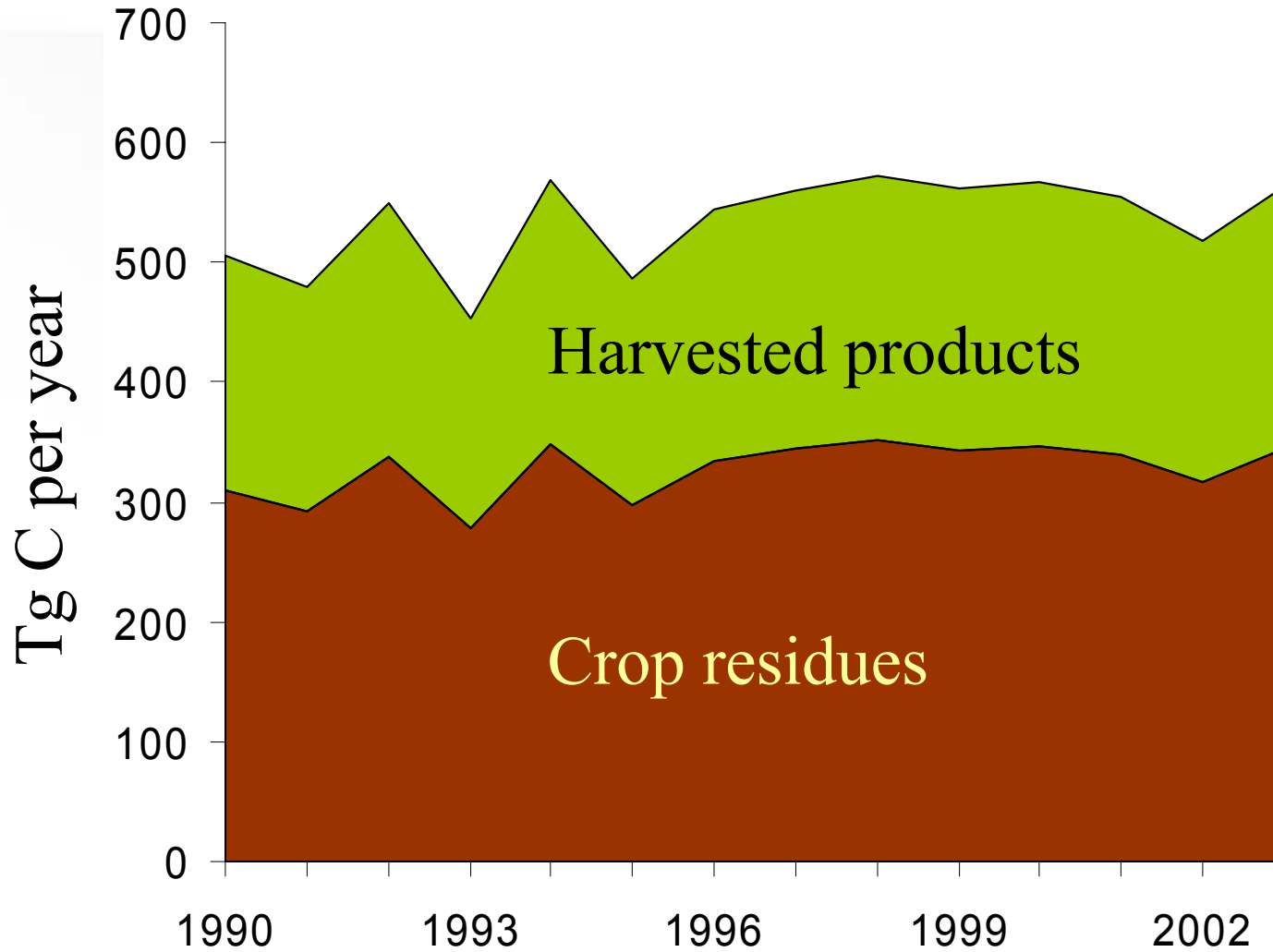
Source: Paustian et al. (2006)

Main points



- 1) Agriculture is a significant emitter of GHGs
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Annual C uptake by cropland



Reducing N₂O and CH₄ Emissions



20-40% reductions in emissions are achievable

Nitrous oxide

- *Improve timing of fertilizer/manure additions*
- *Avoid over-application of fertilizer/manure*
- *Better placement*
- *Use of nitrification inhibitors*

Methane

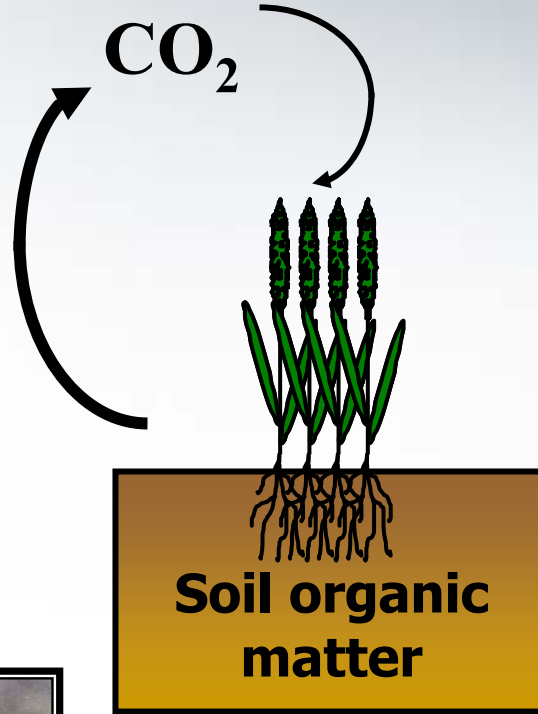
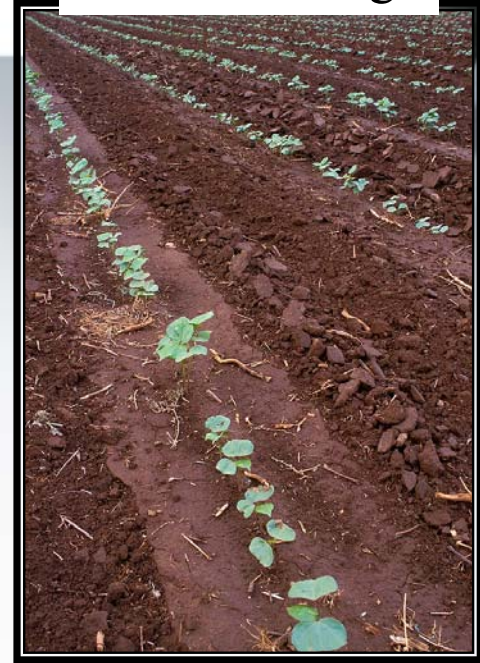
- *Improved livestock breeding and nutrition*
- *Feed additives to inhibit methane (e.g. dairy)*
- *CH₄ capture from manure (biogas)*

Past Agricultural Practices

Erosion



Intensive tillage



Residue removal



Low Productivity



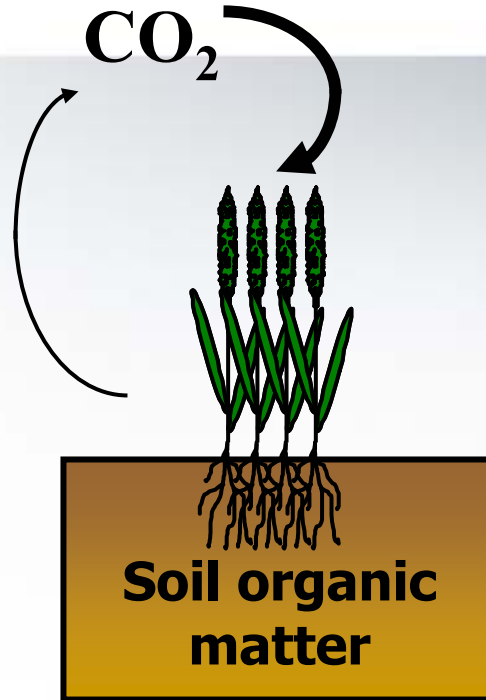
Improved Agricultural Practices



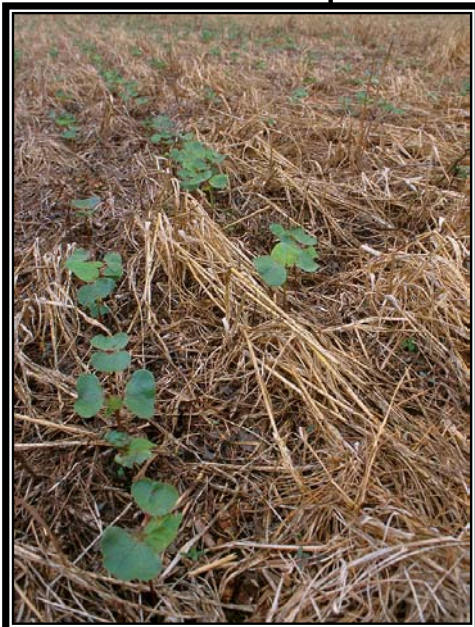
Conservation buffers



Conservation tillage



Cover crops



Improved rotations



CRP



Potential mitigation by US agriculture



Carbon dioxide

- *Carbon sequestration*
- *5-14% of current (2004) total emissions in the US (ca. 100-270 MMT C equivalent), through soil C sequestration and emission reductions from agricultural sources (primarily N₂O and CH₄)*

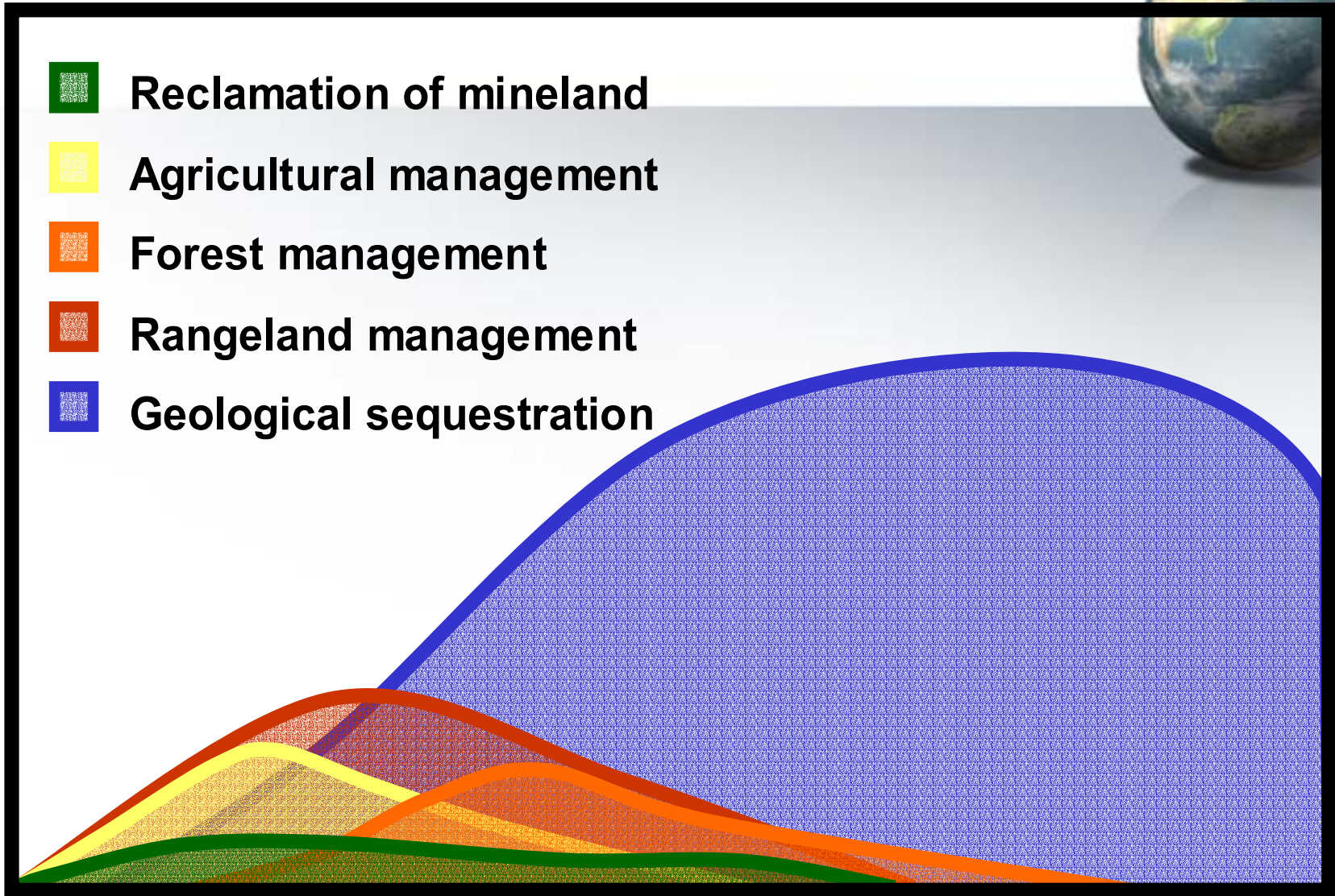
Main points



- 1) Agriculture is a significant emitter of GHGs
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Annual C sequestration (tonnes C)

-  **Reclamation of mineland**
-  **Agricultural management**
-  **Forest management**
-  **Rangeland management**
-  **Geological sequestration**



2010

2020

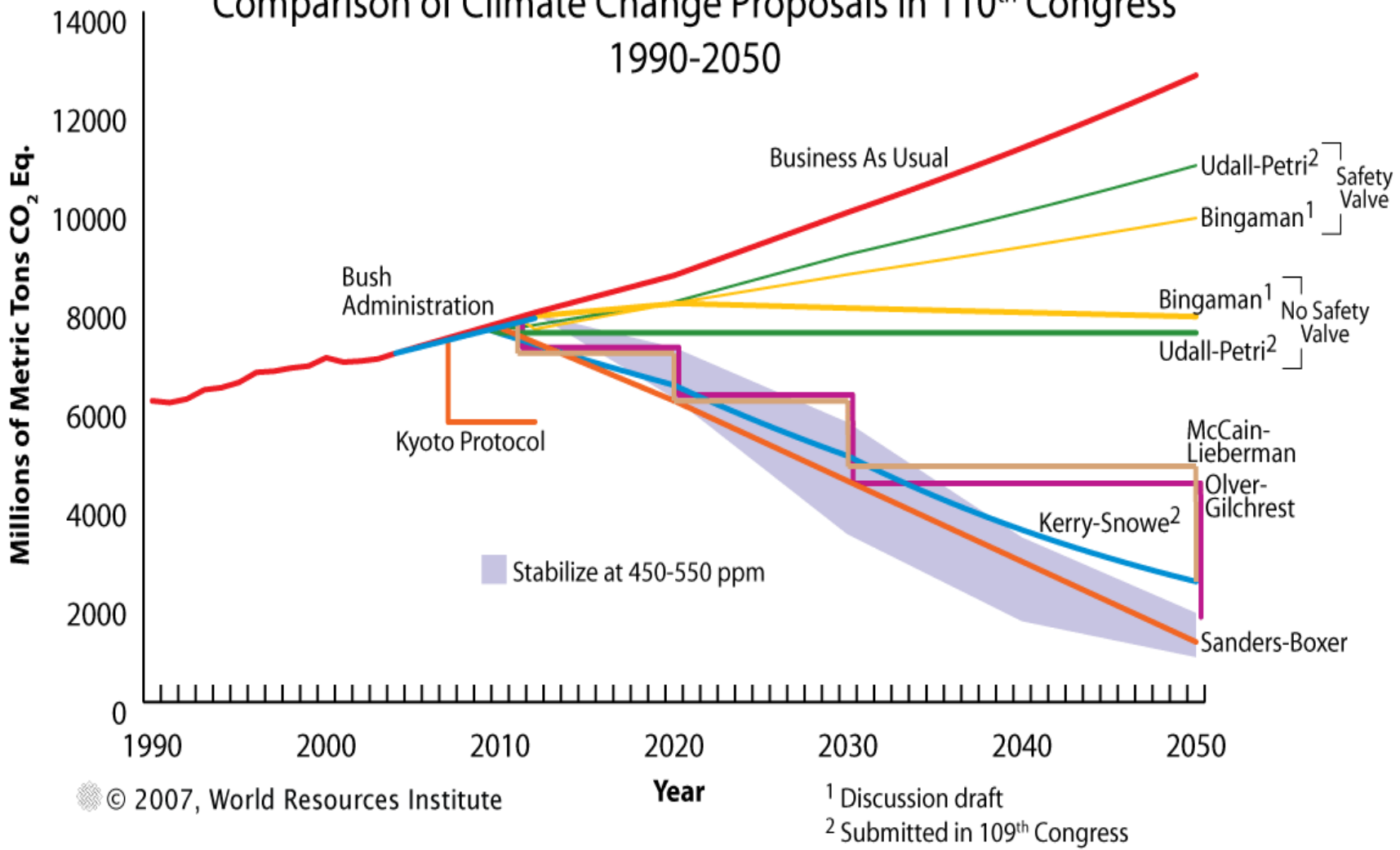
2030

2040





Comparison of Climate Change Proposals in 110th Congress 1990-2050



Sen. Feinstein (utility only)



- 731 Outreach on revenue Enhancement to Ag Producers
- 732 Offset Measurements for Ag, Forestry, Wetland
- 734 Offset Credits for Forest, Grazing, Wetland
- 735 Offset from Avoided Conversion of Forest and Wetland
- 736 Offset for GHG Emission Reduction Projects
 - includes eligibility for uncapped sectors (even beyond agriculture)
- 737 Borrowing against Future Offsets
- 738 Reviewing of Accounting for Offset Credits

Lieberman-McCain (economy-wide)



Sec. 144

- Alternative Measures of Compliance – offsets limited to 30% of total allowances required to cover emissions in any given reporting period.
- If more than 15% of allowances are covered by an alternative measure of compliance, then 1.5% of total must be agricultural soil sequestration, and a report every five years after must be submitted to ensure maintenance of sequestered carbon. Traditional allowances must be relinquished to account for losses

Some farm bill recommendations



- 1) Ensure language includes greenhouse gases specifically as a resource of concern under air quality.
- 2) Ensure conservation programs include opportunities for reductions in all agricultural greenhouse gas emissions, including nitrous oxide and methane and enhanced carbon storage as national priorities.
- 3) Require that environmental tradeoffs are assessed when evaluating applications for cost-share or incentive payments.
- 4) Explicitly specify nitrous oxide and methane mitigation opportunities in any existing climate change language.



What's at Stake?

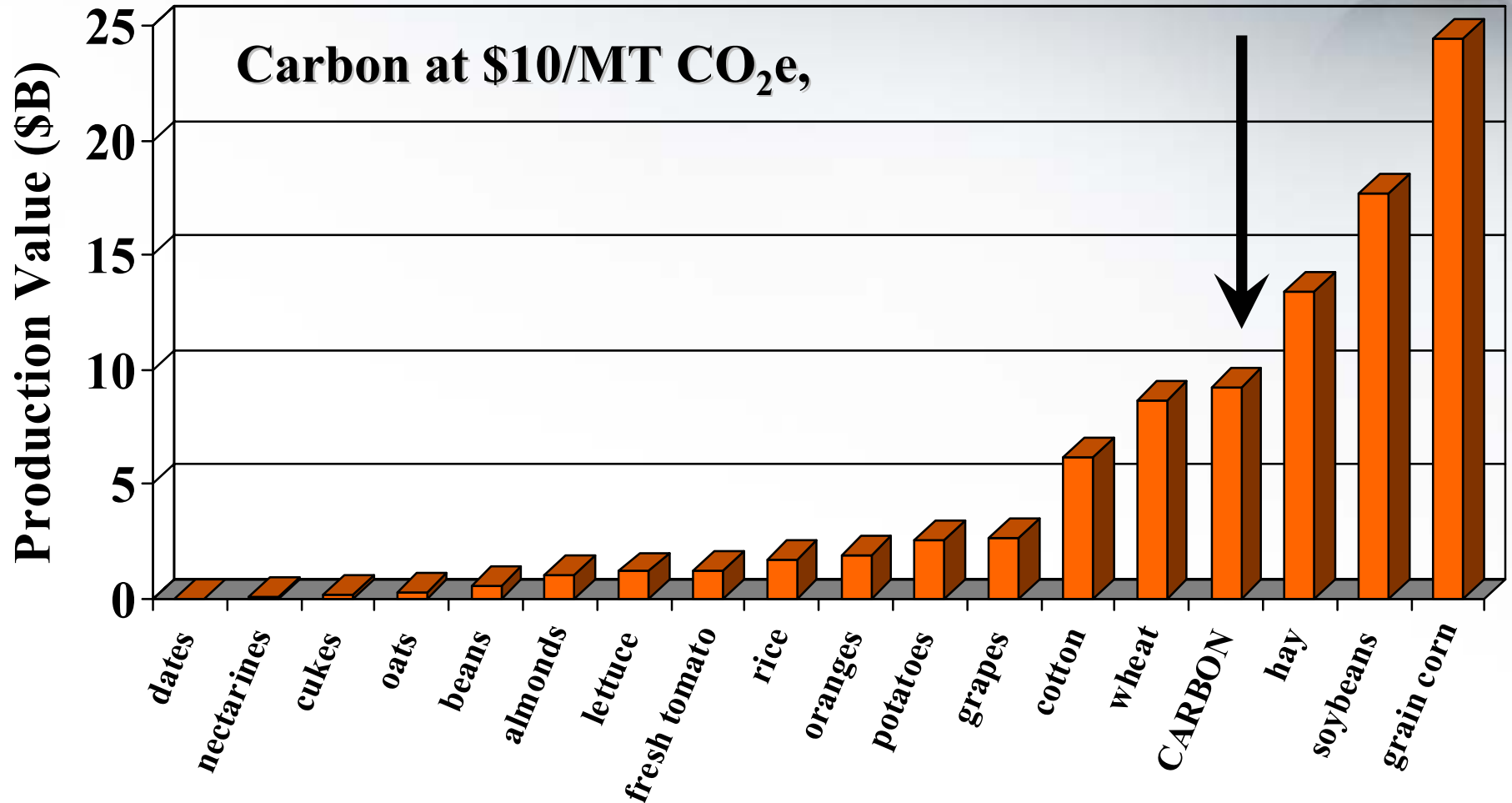
European CO2e Prices – Close 12/06



€/ton CO2



Carbon as a Crop in U.S. per Proposed GHG Limits in Lieberman-McCain



Source: USDA - National Agricultural Statistics Service

Main points



- 1) Agriculture is a significant emitter of GHGs
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- 4) **Methods and tools already exist to quantify GHG emission reductions and soil C sequestration.**

Accounting and Reporting



- Currently, US has ‘voluntary’ programs for GHG reductions (1605B program)
- Bills pending in Congress for mandatory reductions – likely action after 2008
- Currently, GHG reductions being included in criteria for farm support payments
- Need for a user-friendly accounting method for farmers participating in 1605B and subsequent C trading activities
- See *www.cometvr.colostate.edu*

COMET-VR (CarbOn Management and Evaluation Tool – Voluntary Reporting)



Contributors

- ▶ [USDA](#)
- ▶ [USDA GCPO](#)
- ▶ [NRCS](#)
- ▶ [ARS](#)
- ▶ [CSU NREL](#)

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[COMET-VR Tool](#)

- Currently supports soil C change estimates and fuel usage
- N₂O emissions will be incorporated in the next version

Online Tool for Agriculture & Range

COMET-VR is the first OnLine Carbon Estimator Tool from Natural Resources Conservation Service (NRCS) and Natural Resource Ecology Laboratory, (NREL), Colorado State University, (CSU), developed in response to global climate change. This tool estimates carbon that is sequestered in the soil based on land management in agriculture. COMET-VR gives you an idea of the magnitude of agricultural management practices on carbon sequestration. The management practices covered are limited to the most predominant in the MLRA. NRCS specialists and the NRCS NRI were used to identify each practice.

Step 1. Enter the State Information: Select the State where the parcel is located from the list of State Names.

State Selection:

Select a State: Indiana ?

- Colorado
- Connecticut
- Delaware
- Florida
- Georgia
- Idaho
- Illinois
- Indiana
- Iowa
- Kansas
- Kentucky
- Louisiana
- Maine
- Maryland
- Massachusetts
- Michigan

Next

Selection

Session Information: ?

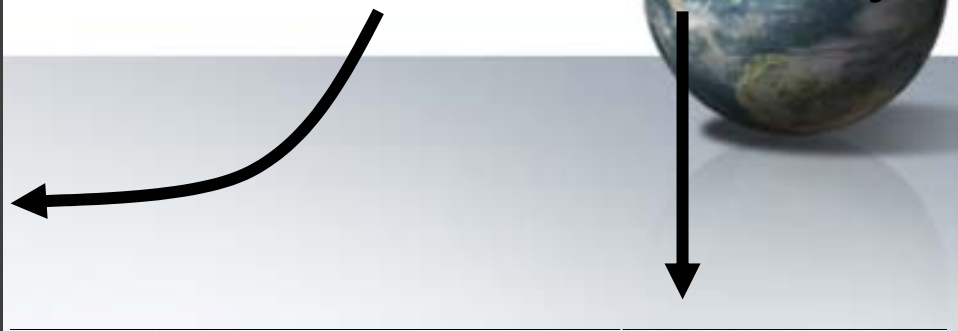
- ID: 1
- ID: 2 122271884
- ID: 3 122272107

Enter Session ID: Go

Location Information:

Parcel Information:

Select state and county



Online Tool for Agriculture & Range

Step 2. Enter the County Information: Select the County where the parcel is located from the list of County Names.

Indiana County Selection:

Select a County: GIBSON ?

- FAYETTE
- FLOYD
- FOUNTAIN
- FRANKLIN
- FULTON
- GIBSON
- GRANT
- GREENE
- HAMILTON
- HANCOCK
- HARRISON
- HENDRICKS
- HENRY
- HOWARD
- HUNTINGTON
- JACKSON
- JASPER

Back

Next

Selection

Session Information: ?

- ID: 1
- ID: 2 122271884
- ID: 3 122272107

Enter Session ID: Go

Location Information:

- State: Indiana

Parcel Information:

Online Tool for Agriculture & Range

Step 4. Enter the Soil Information: Select the dominant soil texture and hydric information for your parcel.

GIBSON County, Indiana Soil Selection

Select the surface soil texture:

- sandy clay loam
- sandy loam
- silt
- silt loam
- silty clay
- silty clay loam

Is this a hydric soil? Select No or Yes:

No Yes ?

Back

Reset

Next

Selection

Session Information: ?

- ID: 1
- ID: 2 122271884
- ID: 3 122272107

Enter Session ID: Go

Location Information:

- State: Indiana
- County: GIBSON
- Fips: 18051
- MLRA: 115A
- LRR: M

Parcel Information:

- Report Date: 2/1/2007
- Name: North Forty
- Size: 40 Acres
- Type: Agriculture

Soil Information:

- Texture: silty clay loam
- Hydric: N

Select soil type and drainage condition



Step 5. Enter the land management information: Choose a rotation for the four time periods. ?

The following cropping systems were identified as having the greatest harvested crop acreage in your county using production data from the National Agricultural Statistics Service and the NRCS Natural Resource Inventory. They may not be the most common cropping systems in your immediate neighborhood but are the most significant cropping systems in your county.

Please select the system that most closely resembles your land management practice. Choose a rotation that is most like your land management that produces a similar residue, and fertilizer application. Or select **Other**. Other represents the most dominate cropping system for your county according to current data.

GIBSON County, Indiana Management History for North Forty:

Choose A Rotation for each Management Time Period:

All Rotations

1. Landscape position and historical management:

- Livestock Grazing (pre 1970s)
- Lowland Non-Irrigated (pre 1970s)
- Upland Non-Irrigated (pre 1970s)

Sort By: Non-Irrigated Irrigated Grazing AgroForestry All

Number of Records: 3

All Rotations

2. 1970s through mid-1990s:

- Livestock Grazing: seasonal, heavy grazing, low fertilizer
- Livestock Grazing: year round, heavy grazing, low fertilizer
- Non-Irrigated: corn-soybean
- Non-Irrigated: corn-soybean-winter wheat
- Other

Sort By: Non-Irrigated Irrigated Grazing AgroForestry OTHER ALL

Number of Records: 5

Conservation Reserve Program (CRP) Enrollment during 1980s? Select the CRP type:

- 100% grass
- grass/legume mixture
- None

All Rotations

3. Base (Current Management):

- Non-Irrigated: corn-oats-5 yrs grass/legume pasture
- Non-Irrigated: corn-sorghum
- Non-Irrigated: corn-soybean
- Non-Irrigated: corn-soybean-5 yrs legume hay
- Non-Irrigated: corn-soybean-winter wheat
- Non-Irrigated: corn-winter wheat

Sort Non-Irrigated Irrigated Grazing AgroForestry CRP OTHER

By: ALL

Number of Records: 35

All Rotations

4. 2007 Report Period:

- Non-Irrigated: corn-oats-5 yrs grass/legume pasture
- Non-Irrigated: corn-sorghum
- Non-Irrigated: corn-soybean
- Non-Irrigated: corn-soybean-5 yrs legume hay
- Non-Irrigated: corn-soybean-winter wheat
- Non-Irrigated: corn-winter wheat

Sort Non-Irrigated Irrigated Grazing AgroForestry CRP OTHER

By: ALL

Number of Records: 35

[Back](#)

[Reset](#)

[Next](#)

Selection

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- ID: 1
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- ID: 3 122272107

Enter Session ID: [Go](#)

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Parcel Information:

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- Name: North Forty
- Size: 40 Acres
- Type: Agriculture

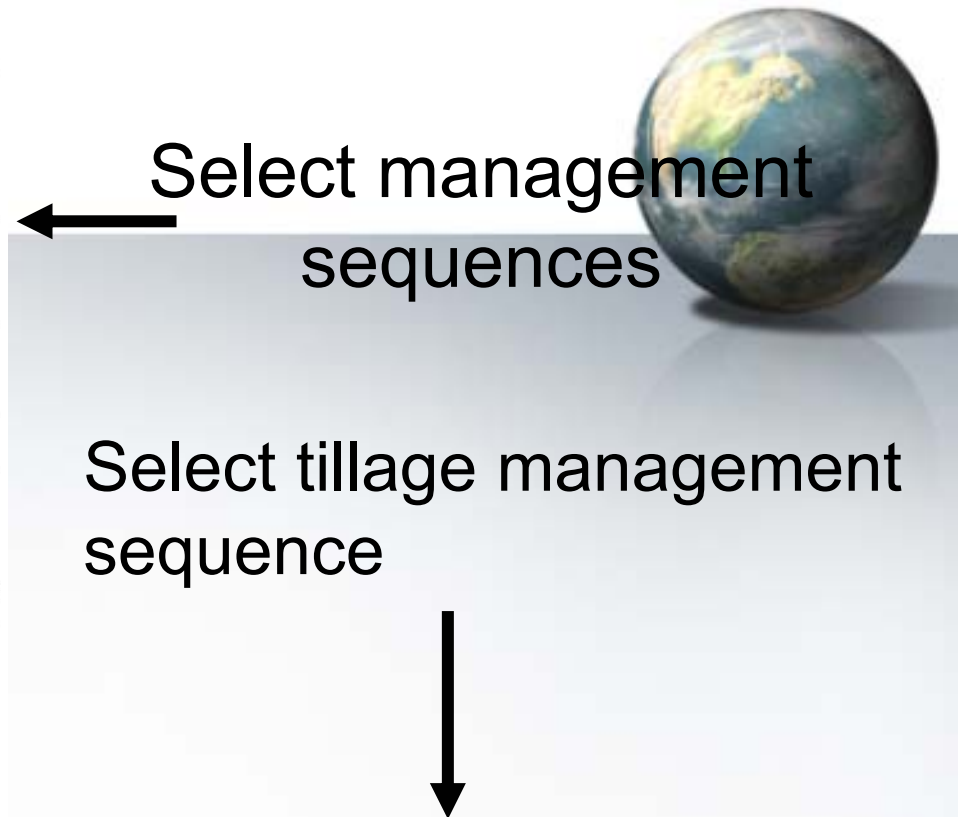
Soil Information:

- Texture: silty clay loam
- Hydric: N

Management History:

See Also

- NRCS Energy Estimator for Tillage
- NREL Agroecosystems
- CASMGS Consortium for Agricultural Soils Mitigation of Greenhouse Gases
- ARS Research
- U.S. Agriculture & Forestry Greenhouse Gas Inventory
- Greenhouse Gas Reporting Guidelines
- Greenhouse Gas Guidance for FARMS and FORESTS
- Draft 1605b Technical Guidelines
- 1605b Voluntary Reporting Program
- COLE Forestry Model
- COLE Lite Forestry Model



Select management sequences

Select tillage management sequence

You are here: [Home](#) / [Online Tool](#)

Online Tool for Agriculture & Range

Step 6. Enter the land management information: Choose a tillage for the three time periods.

GIBSON County, Indiana Tillage History for North Forty

Enter the management history for this parcel: ?

Tillage For this Time Period:

1970s through mid-1990s:

Choose Tillage:

- Intensive Tillage
- Reduced Tillage
- No Till Tillage

Base (Current Mgmt.):

- Intensive Tillage
- Reduced Tillage
- No Till Tillage

2007 Report Period:

- Intensive Tillage
- Reduced Tillage
- No Till Tillage

[Back](#)

[Reset](#)

[Next](#)

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- Size: 40 Acres
- Type: Agriculture

Soil Information:

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- Hydric: N



Output: Carbon sequestration


Voluntary Reporting Carbon Management Tool COMET-VR

Carbon Storage Report

Report Year: 2008

Session ID: 712351316

Parcel Description		Parcel Management History
Parcel Type:	Agriculture	Historic: Irrigation (pre 1970s) Irrigated: 5 yrs
Total Parcels for this Entity:	1	70s to 90s: grass/legume hay; Intensive Tillage
Parcel Name:	Parcel 1	Current: Irrigated: 2 yrs corn for silage-4 yrs alfalfa hay; No Till Tillage
Parcel Size:	100 Acres	Report Period: Irrigated: 2 yrs corn for silage-4 yrs alfalfa hay; Intensive
Location:	LARIMER, Colorado	
Soil:	Non-hydric clay	

	Carbon Change	Uncertainty 		
		Avg Percent	Lower Bounds CI*	Upper Bounds CI*
Total Tons Carbon per year:	-40.23	Unknown		
Total Tons CO2 Equivalent per year:	-147.52	Unknown		

Values recorded in English units. One ton of carbon is equivalent to 3.667 tons of carbon

Output: Fuel and fertilizer use

Carbon Management Tool Fuel & Fertilizer

Report Date: 2008
Parcel Description: Parcel 1,
LARIMER County, Colorado

	1999 to 2008* Base (Current Management)	2009 to 2018* Report Period
Average Yearly No. 2 Diesel Use from Tillage	420.00 Total Gallons	864.00 Total Gallons
Average Yearly Nitrogen Fertilizer Use	5,460.14 Total Lbs	5,460.14 Total Lbs

* Values calculated from the Dynamic LRR database for 2008

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