Crop Management Strategies to Enhance Soil Carbon Sequestration

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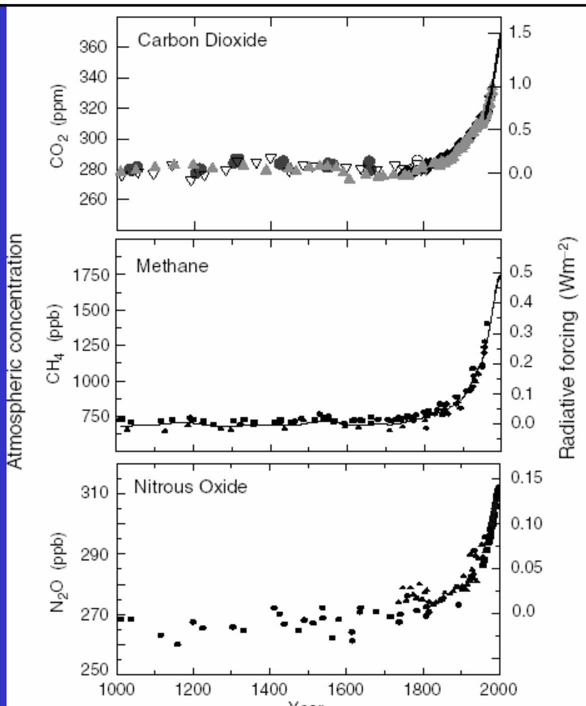
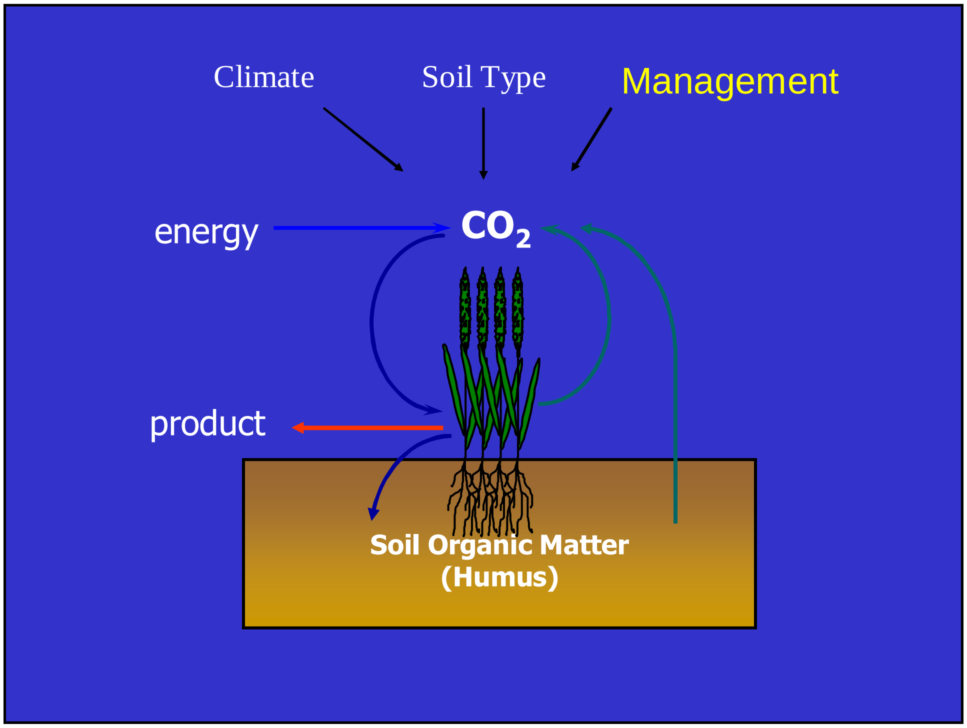
CASMGS
Consortium for Agricultural Soils Mitigation of Greenhouse Gases

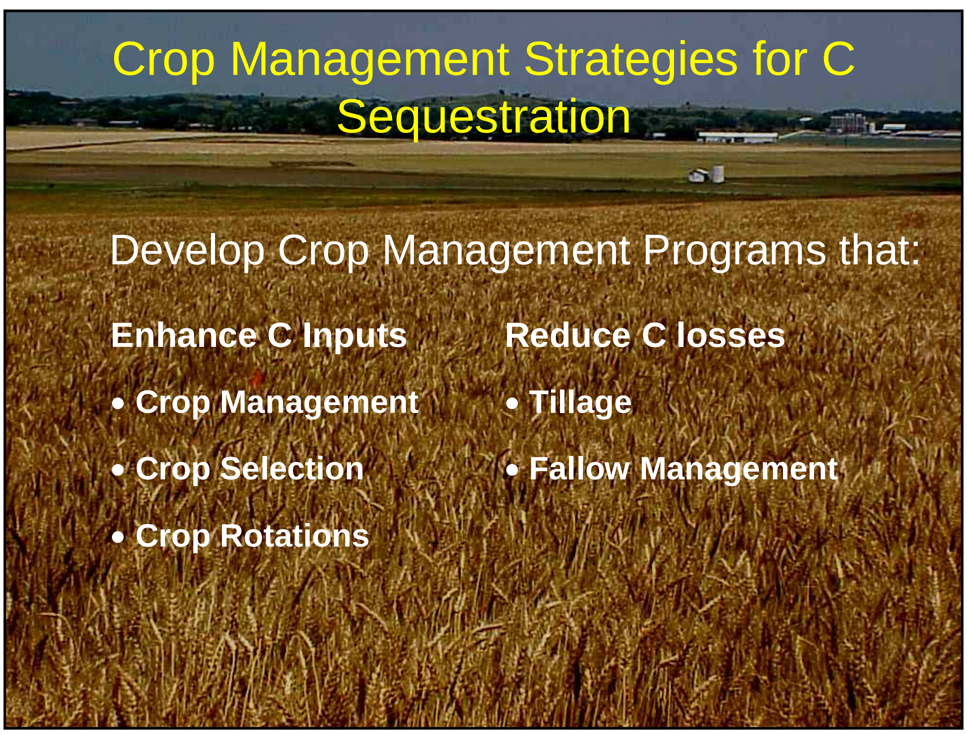
K-State Research and Extension

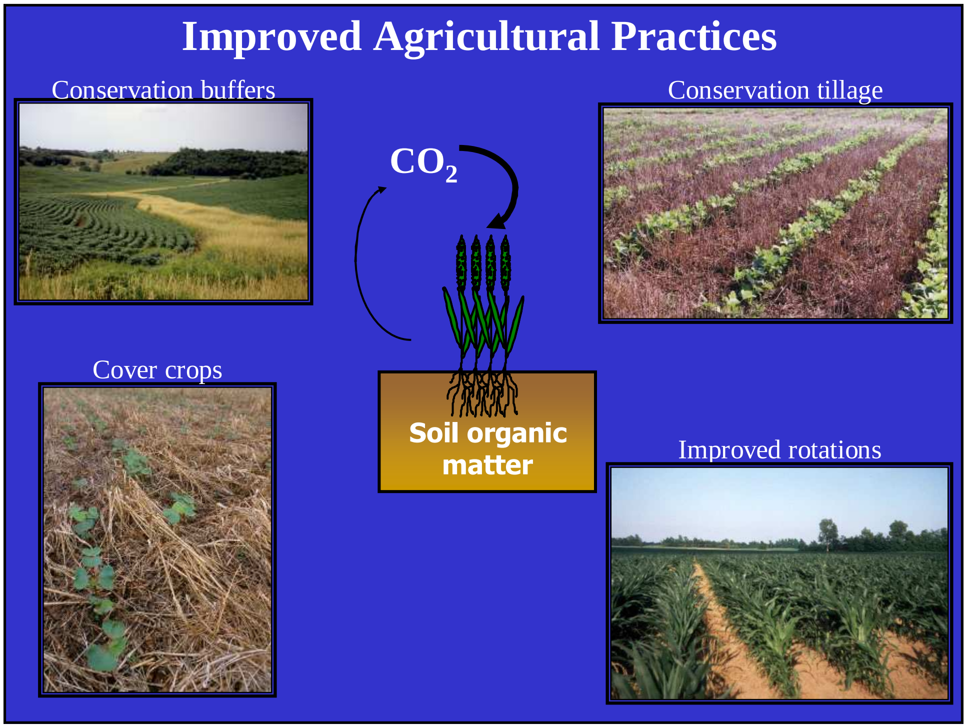


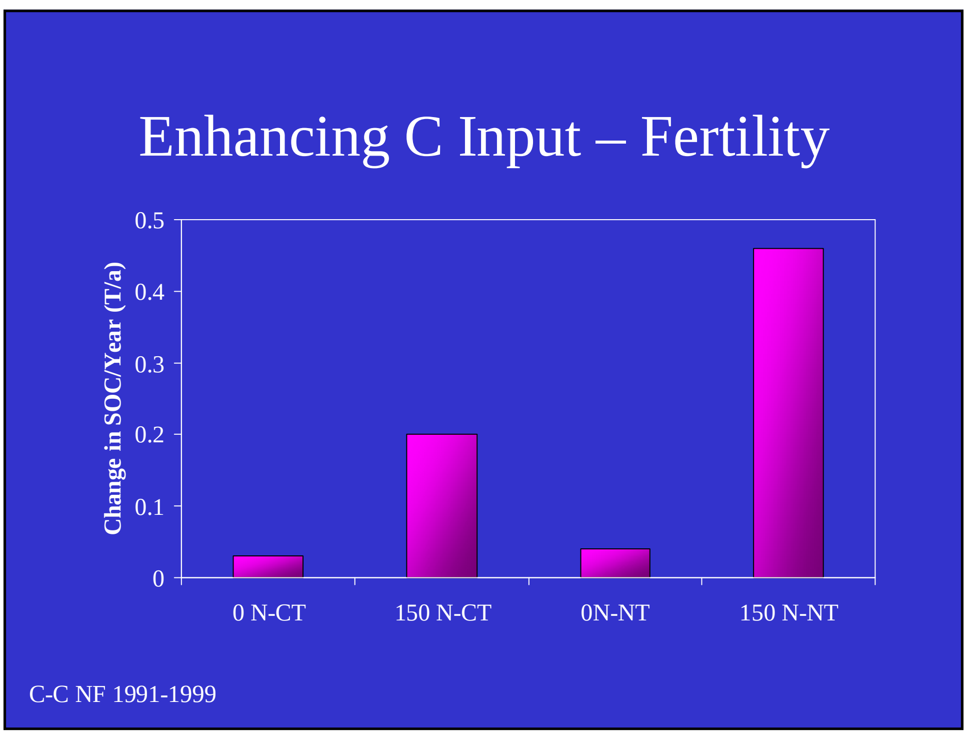
Atmospheric Concentrations of CO_2, Methane (CH_4), and Nitrous Oxide (N_2O) from 1000 A.D.

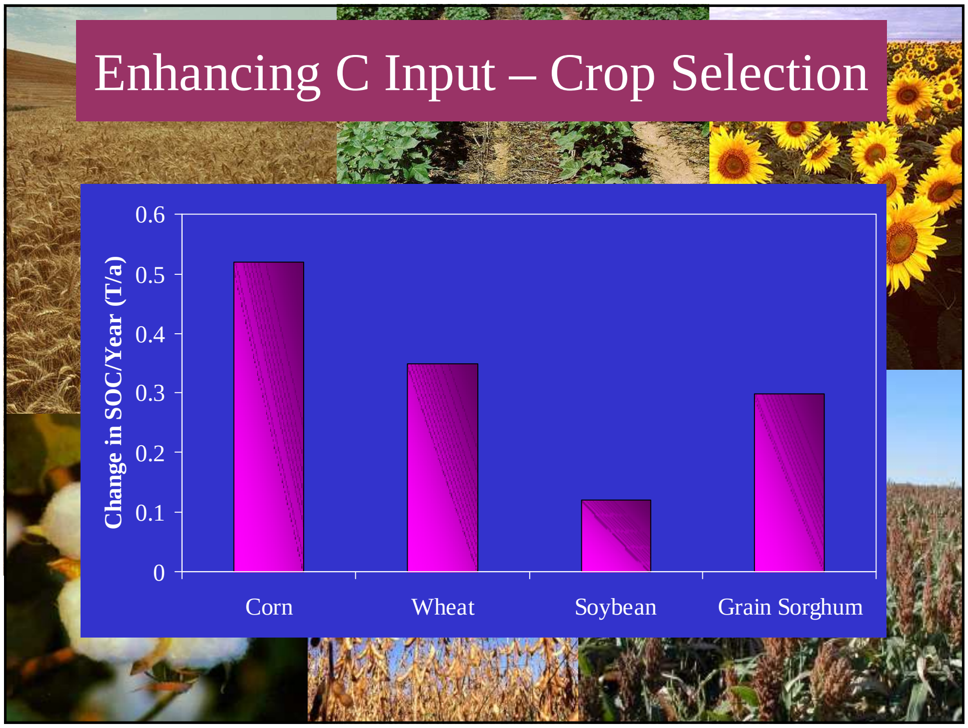
From IPCC (2001)

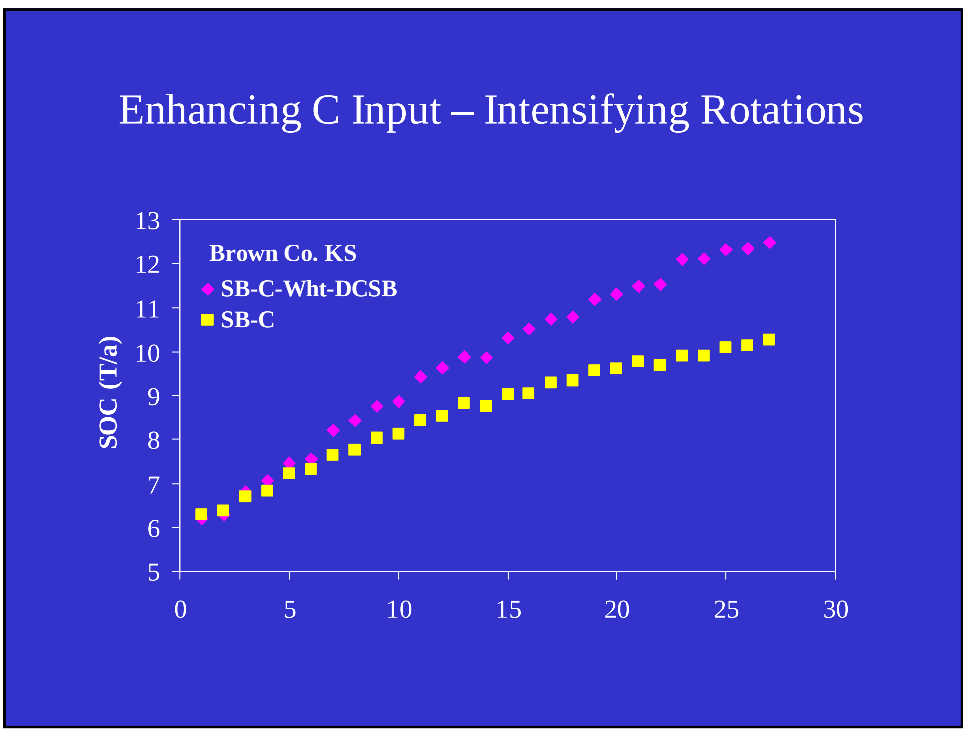

Climate
Soil Type
Management
energy
CO_2
product
Soil Organic Matter
(Humus)


Crop Management Strategies for C Sequestration
Develop Crop Management Programs that:
Enhance C Inputs
• Crop Management
• Crop Selection
• Crop Rotations
Reduce C losses
• Tillage
• Fallow Management


Improved Agricultural Practices
Conservation buffers
Conservation tillage
CO2
Cover crops
Soil organic matter
Improved rotations

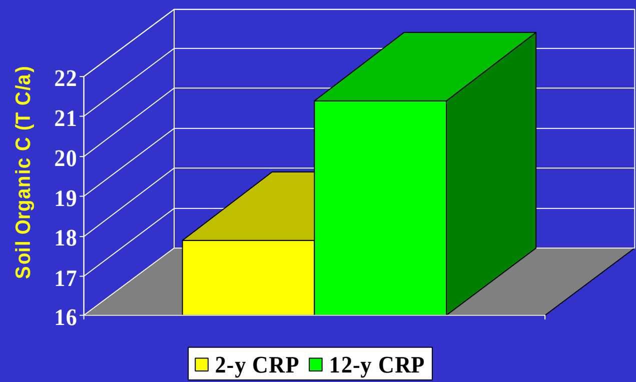

Enhancing C Input – Fertility
Change in SOC/Year (T/a)
0.5
0.4
0.3
0.2
0.1
0
0 N-CT
150 N-CT
0N-NT
150 N-NT
C-C NF 1991-1999


Enhancing C Input – Crop Selection
Change in SOC/Year (T/a)
0.6
0.5
0.4
0.3
0.2
0.1
0
Corn
Wheat
Soybean
Grain Sorghum


Enhancing C Input – Intensifying Rotations
SOC (T/a)
Brown Co. KS
SB-C-Wht-DCSB
SB-C
13
12
11
10
9
8
7
6
5
0
5
10
15
20
25
30

Soil organic C after 2 and 12 y of CRP in Nebraska (Baer, Kitchen, Blair, and Rice)

0.4 tons/a/y



Fire (Eastern Kansas) – after 10 Years (T C a^{-1})

Treatment	Total C
Control	20.4
Annual Burning	21.4

Crop Management Strategies for C Sequestration

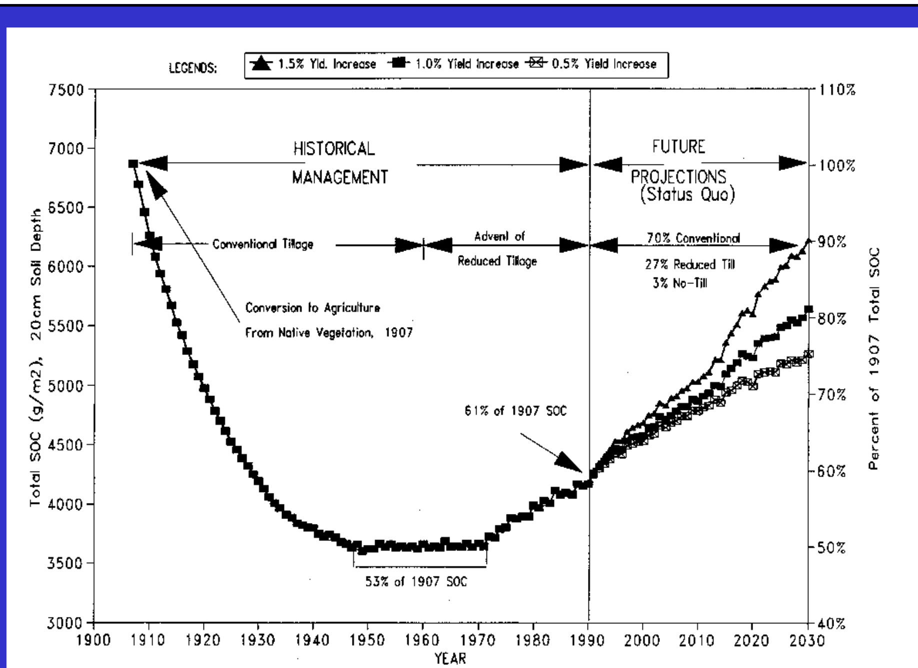
Develop Crop Management Programs that:

Enhance C Inputs

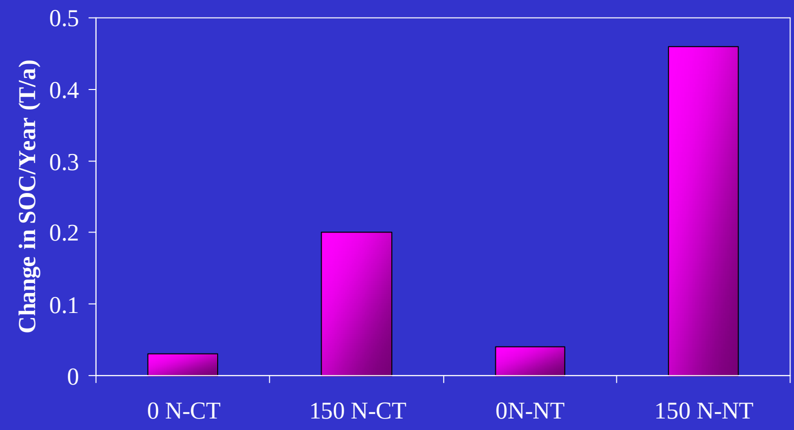
- **Crop Management**
- **Crop Selection**
- **Crop Rotations**

Reduce C losses

- **Tillage**
- **Fallow Management**

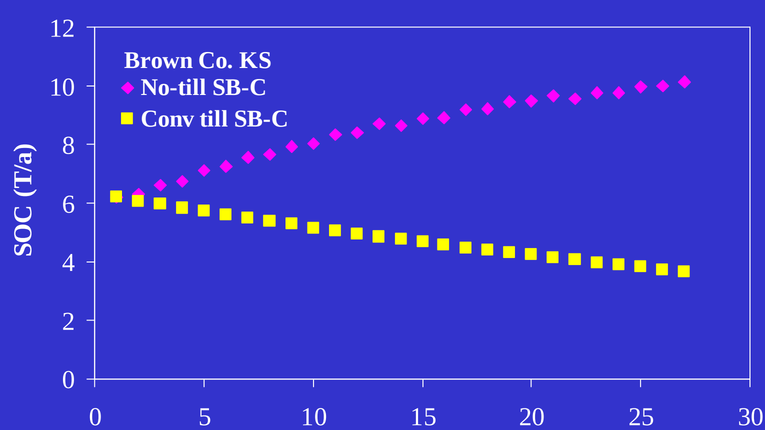


Enhancing C Input – Tillage

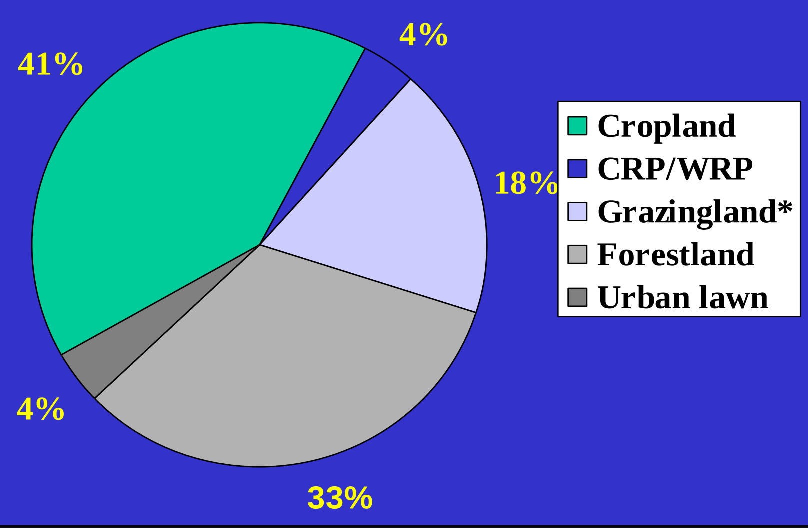


C-C NF 1991-1999

Reducing Loss – Reducing tillage



Soil C sequestration potential of different US land Categories (% of 322 MMT C/yr) **



United States efforts in Agriculture

- Federal government established a goal of 18% improvement in GHG efficiency (Roughly a reduction of 100 Mt carbon)
- USDA is utilizing conservation programs to encourage carbon sequestration and GHG reductions
  - GHG offsets are factors in setting priorities under:
    - The Environmental Quality Incentives Program
    - The Conservation Reserve Program
    - The Forest Land Enhancement Program
- Federal government challenged the private sector to take action
  - USDA is working with the Department of Energy to improve the voluntary GHG reduction registry
  - USDA is negotiating voluntary agreements with businesses and sectors
  - Several corporations are undertaking projects in partnership with farmers and land owners

Carbon Credits/Trading

- Carbon reduction
  - C reduction at point of emissions
  - C reduction by sequestration

- Is it cheaper to buy a credit than control emissions?

What is needed

- Sellers of C credits: Land managers
- Aggregator
- Buyers
- Monitoring/Verification

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

Izaurralde (2004)

Kansas Coalition for Carbon Management

- **Mission**
  - **To inform, educate and motivate land managers to apply management practices that result in reduced atmospheric carbon levels**

- Website
  - www.oznet.ksu.edu/kccm

KCCM
Kansas Coalition for Carbon Management

Kansas Coalition for Carbon Management

Member Organizations

- Kansas Resource Conservation and Development Councils
- Kansas Corn Growers Association
- Kansas Grain Sorghum Producers Association
- Kansas Association of Wheat Growers
- Kansas Electric Power Cooperative
- Kansas Forage and Grasslands and Society for Range Management
- Kansas Livestock Association
- Kansas Farm Bureau
- Kansas Rural Center
- Kansas Association of Conservation Districts
- Kansas Department of Agriculture
- State Conservation Commission
- Kansas Department of Health and Environment
- USDA Natural Resources Conservation Service
- USDA Farm Services Agency
- Kansas Sate University

KCCM
Kansas Coalition for Carbon Management

Questions

Treatment	Scenario	Rate (Mg C/ha/y)	Duration (yrs)	State
Eliminate summer fallow	3-year system 4-year system Continuous cropping	0.073 0.117 0.229	12	Eastern Colorado
Integrated Nutrient Management (corn)	NT 150 N manure NT 150 N Fert CT 150 N manure	1.19 1.05 1.01	10	NE Kansas
Rotations	CT - NT wheat CT - NT sorghum CTsorg/NTwheat to NT sorg/wheat	0.764 0.605 0.624	10	SC KS
Conservation tillage	wheat/sorghum/fallow rotation	0	37	Semi-arid KS
CRP		0.80	12	NE

Corn production relative to conventional tillage in NE KS (10 years)

	CT-168-M	NT-84 F	NT-168 F	NT-84M	NT-168M
Mean Yield (Bu/a) (85.8)	77.9	75.7	**87.6**	69.2	74.3
Net Return ($/a) (39.19)	22.86	63.48	**73.28**	51.43	44.04
Soil C (MT C/ha/y)	1.01	0.13	**1.05**	0.22	1.19
Net C (MT C/ha/y)	1.08	0.02	**1.08**	0.29	1.25

Pendell et al. 2004

Sorghum and wheat production in SC KS (10 years)

	CT-WW	CT-SS	CTS-NTW	NT-SS	NTS-NTW
Net Return ($/ha)	20.24	**63.51**	**54.26**	**58.29**	45.62
Soil C (MT C/ha/y)	1.34	0.27	0.83	0.88	**1.48**
Emissions from Inputs (MT C/ha/y)	0.11	0.12	0.11	0.13	0.12
Net C (MT C/ha/y)	1.23	0.15	**0.73**	**0.76**	**1.35**

Williams et al. 2004

Why Tillage

- Eliminate soil compaction
- Control weeds
- Eliminate residue
  - Harbor insects and diseases
  - Tie up fertilizer N
  - Barrier for herbicide
- What hard working people do
  - Sense of accomplishment
  - Cleansing operation
  - Why not?

Because it causes soil erosion and reduces soil organic matter

- Websites

  www.oznet.ksu.edu/kccm

  www.soilcarboncenter.k-state.edu/

  www.oznet.ksu.edu/ctec

  www.casmgs.colostate.edu/

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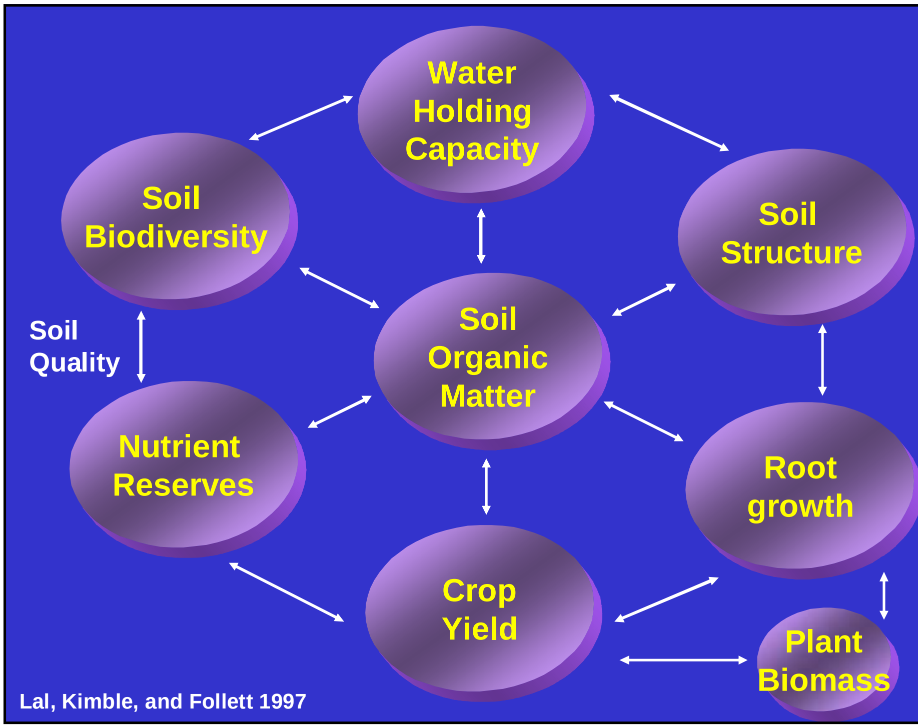
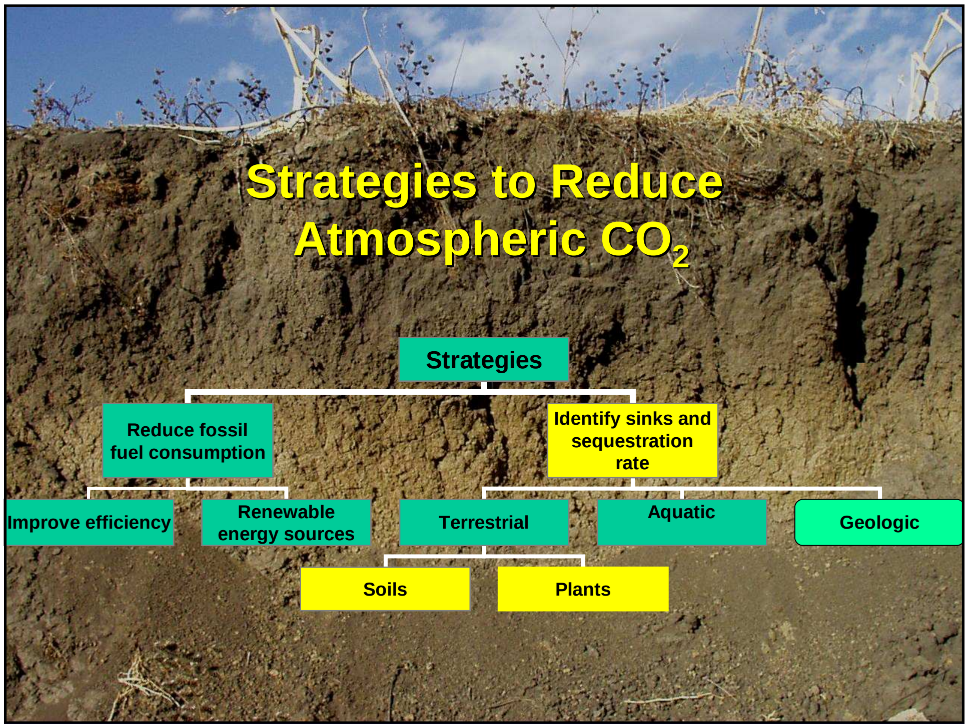
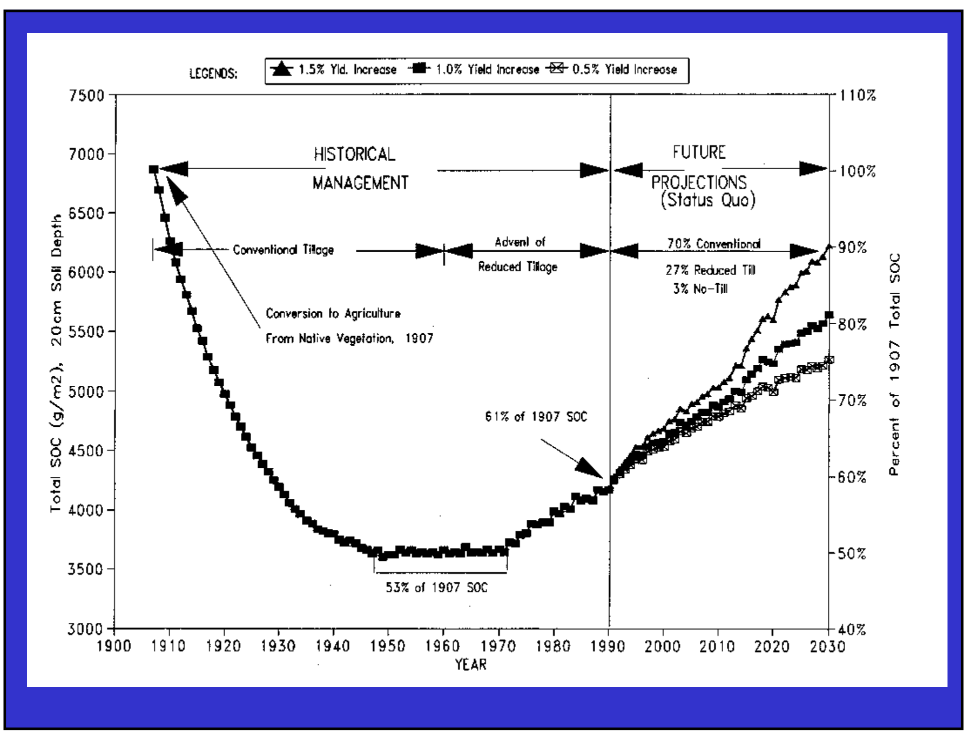
K-State Research and Extension



Lal, Kimble, and Follett 1997


Strategies to Reduce Atmospheric CO_2
Strategies
Reduce fossil fuel consumption
Identify sinks and sequestration rate
Improve efficiency
Renewable energy sources
Terrestrial
Aquatic
Geologic
Soils
Plants


LEGENDS: 1.5% Yld. Increase 1.0% Yield Increase 0.5% Yield Increase
HISTORICAL MANAGEMENT
FUTURE PROJECTIONS (Status Quo)
Conventional Tillage
Advent of Reduced Tillage
70% Conventional
27% Reduced Till
3% No-Till
Conversion to Agriculture From Native Vegetation, 1907
61% of 1907 SOC
53% of 1907 SOC
Total SOC (g/m2), 20cm Soil Depth
Percent of 1907 Total SOC
YEAR
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
110%
100%
90%
80%
70%
60%
50%
40%
1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 2020 2030

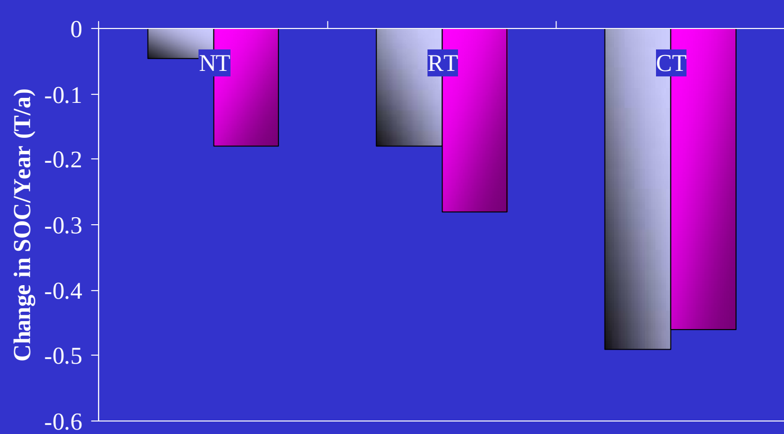
Potential of U.S. Agriculture for Mitigation

Scenario	MMTC/yr
C sequestration in cropland	132
C sequestration in CRP	13
C sequestration in rangelands	58
Biofuel production (C offset)	~50
Saving in fuel consumption	1-2
Reduction of C emission from eroded sediments	~15
Total	270

US emissions: ~1750 MMTC/yr

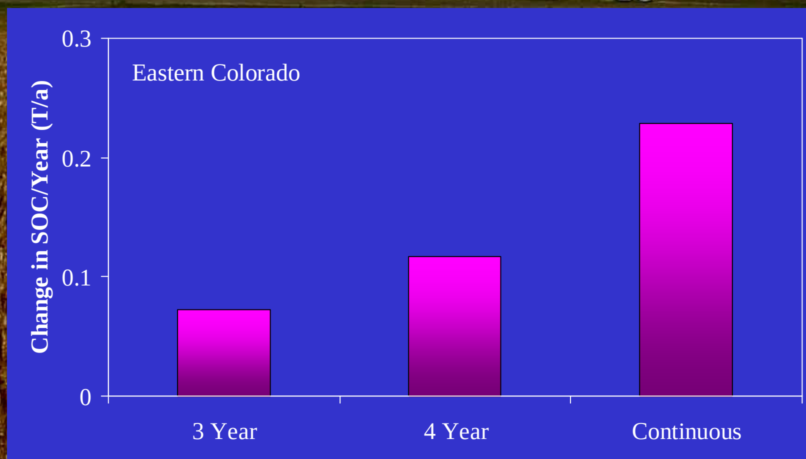
Lal et al., 1999, 2003

Enhancing C Input – Tillage



NE W-F 1970-1990

Crop Management Strategies for C Sequestration



Crop Management Strategies for C Sequestration

Enhance C Inputs

- **Crop Rotations**

Reduce C losses

Fallow Management

•To increase soil carbon levels, we need crop rotations that reduce fallow periods.

•Especially rotations with fallow periods during the summer when temperatures result in maximum soil respiration rates.

Land Use for C Sequestration Management Strategies

Land Use

- Cultivation
- Rangeland
- Forestry

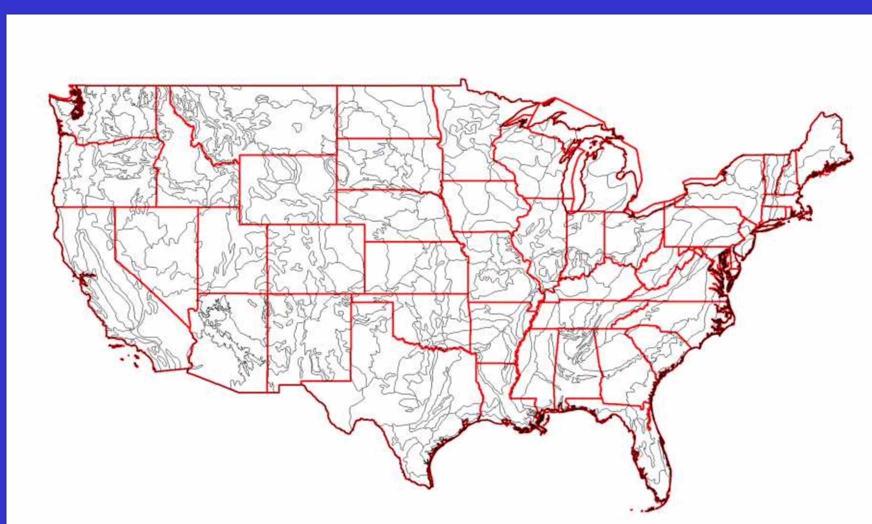
Soil Management

- Tillage
- Residue Management
- Fertility
- Water
- Erosion Control

Crop Management

- Varieties
- Crop Rotations
- Cover Crops
- CRP

US Major Land Resource Areas



Kansas MRLAs and Carbon Pilot Counties