Indiana Certified Crop Advisors Conference

14-15 December, 2004 Indianapolis, IN

Tillage Effects on Gas Exchange and Soil Organic Matter.

by

D.C. Reicosky

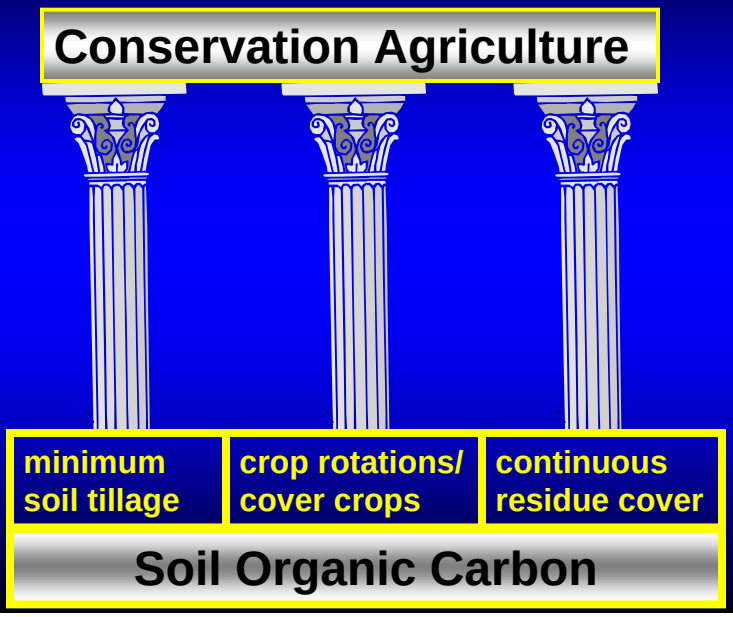
USDA

Agricultural Research Service

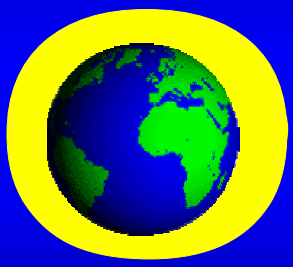
USDA-ARS-MWA

North Central Soil Conservation Research Laboratory Morris, MN USA

3 Pillars of Conservation Agriculture!



We have only



ne Earth!

Global Environmental Concerns

Increasing Global Population

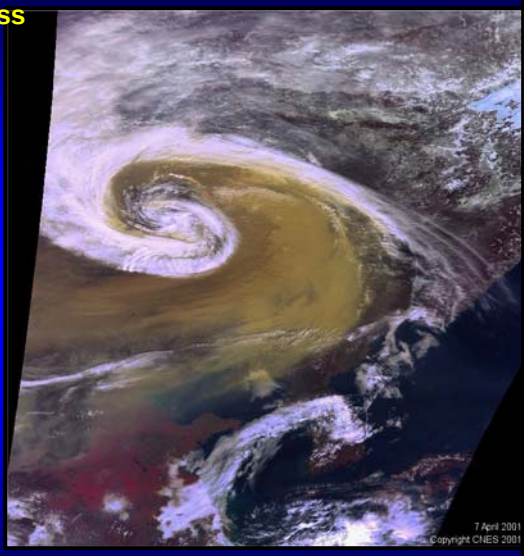
Decreasing Agricultural Producers

The solution is Conservation Agriculture.

DUST BOWL THREATENING CHINA'S FUTURE Lester R. Brown

China Dust storm 2000 km across (07/04/2001)

News reports typically attribute the dust storms to the drought of the last three years, but the drought is simply bringing a fast-deteriorating situation into focus. Human pressure on the land in northwestern China is excessive. There are too many people, too many cattle and sheep, and too many plows. Feeding 1.3 billion people, a population nearly five times that of the United States, is not an easy matter.



The VEGETATION images show the storm over China, Mongolia, North and South Korea, where dust transport is clearly visible. The image is of April 7th , 2001.

Many water quality problems are a result of intensive tillage and rainfall that leads to erosion and sedimentation.

The National Academy of Sciences panel agreed that agriculture and storm runoff are jeopardizing water quality in about 21,000 bodies of water in the U.S.---from lakes and ponds to segments of streams and major rivers---that were determined to be too polluted for fishing and swimming.

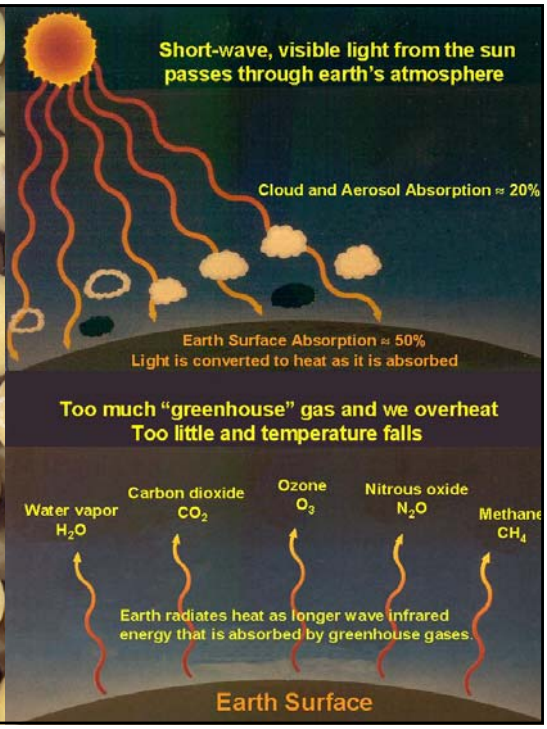
Source: Associated Press, 16 June, 2001

Conservation Agriculture is carbon management. Conservation Agriculture is good for a lot of reasons. Climate change is just one of those reasons.

Global Perspective

Greenhouse Effect and Global Climate Change

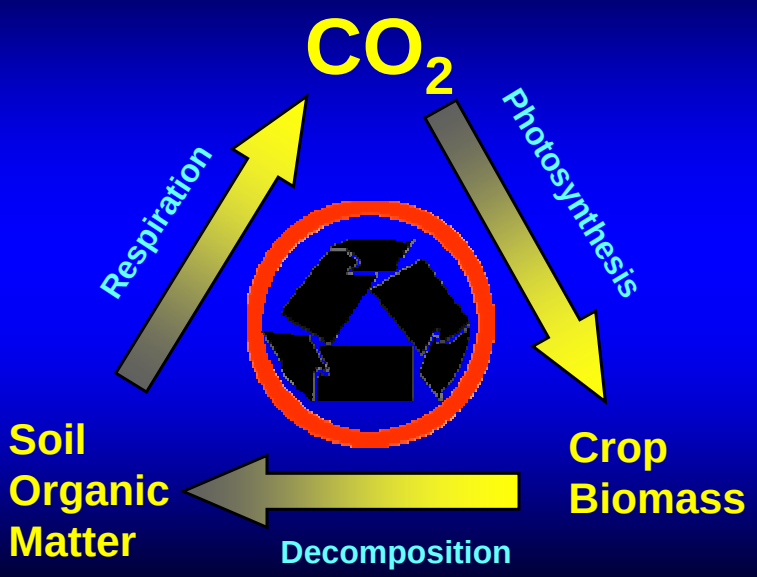
The role of agricultural tillage and soil carbon



No. 1 Environmental Enemy in Production Agriculture

Intensive Tillage

Carbon Cycle in Agriculture



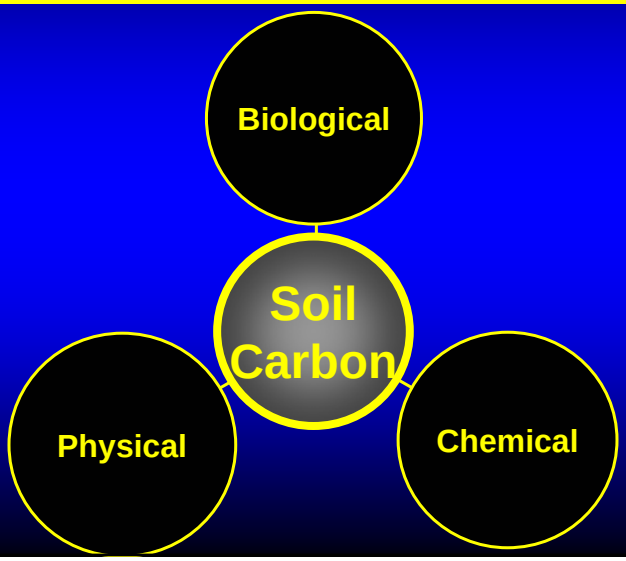
True Conservation Agriculture is carbon management.

Conservation agriculture provides beneficial ecosystem services:

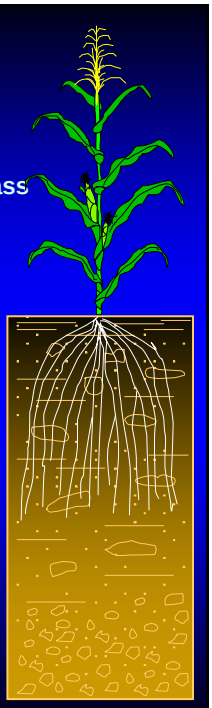
1. Food and fiber and biofuels
2. Less erosion, less pollution, clean water, fresh air, healthy soil, natural fertility, higher production, carbon credits, beautiful landscape, sustainability etc., etc. ……

Soil carbon is a priceless key to the planet's health and our environmental quality.

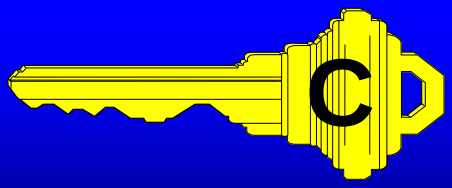
Soil carbon is linked to all measures of soil quality.



Soil organic matter is a mixture of residual **plant material** in various stages of decomposition and microbial biomass and all their bi-products.



The "key" component is:



carbon!

Incorporating crop residues with intensive tillage maximizes residue-soil contact and is the fastest way to convert soil organic matter to a "puff" of carbon dioxide.

4 E's of Conservation Agriculture

C — **Sustainable Production**

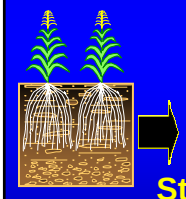
Credit: Victor Trucco, Roberto Peiretti

Carbon Cycle - a "fantastic voyage"

CO_2

Green plants

Crop Residue/Stubble Decomposition Cycle as a temporal continuum with carbon changing form and function as CO_2 is released through microbial respiration.



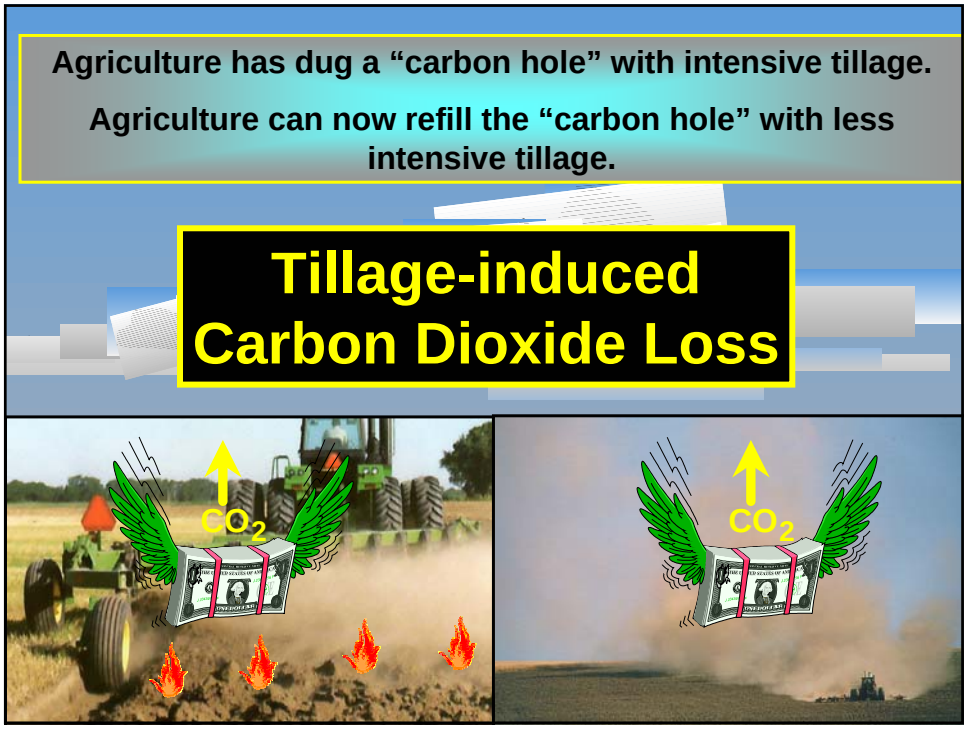
CO_2 CO_2 CO_2 CO_2 CO_2 Basic elements

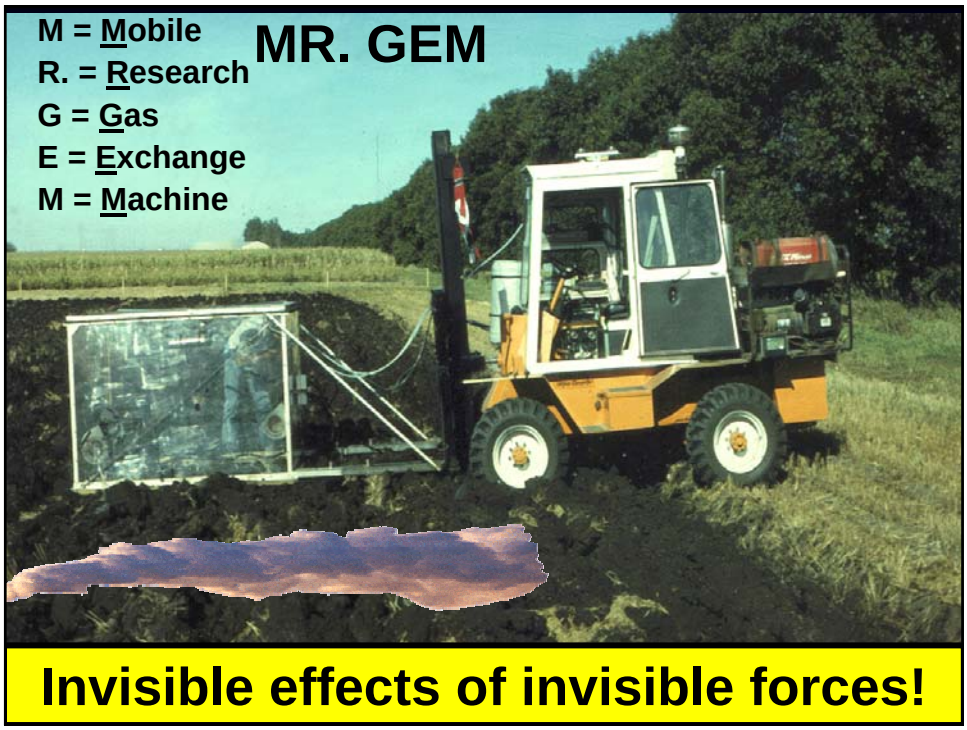
Stubble residue

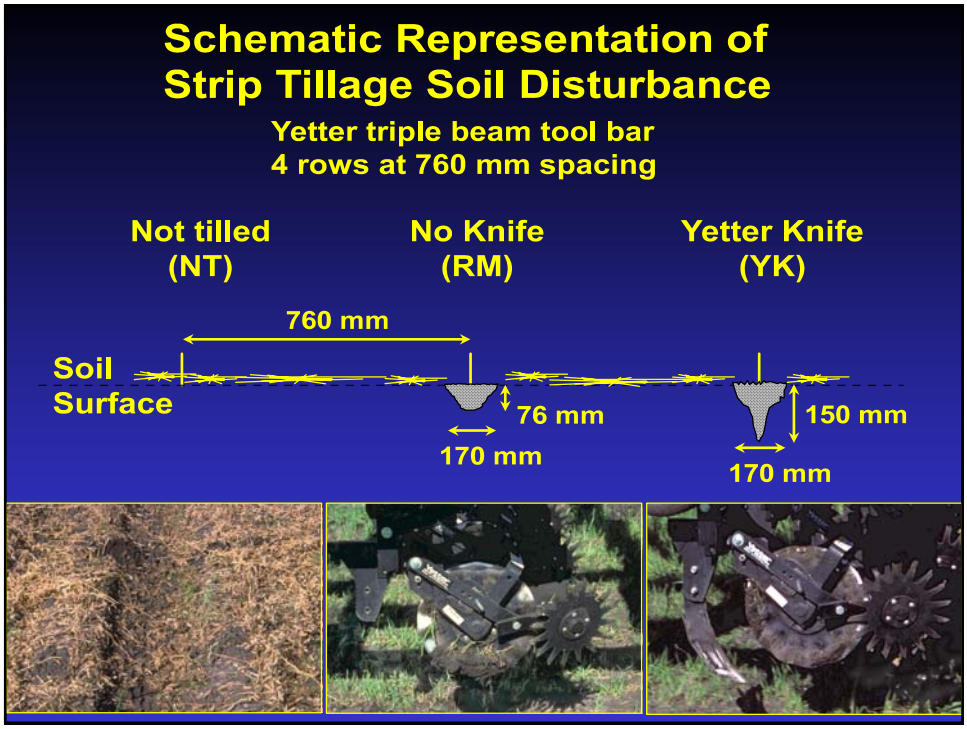
Organic matter --- humus

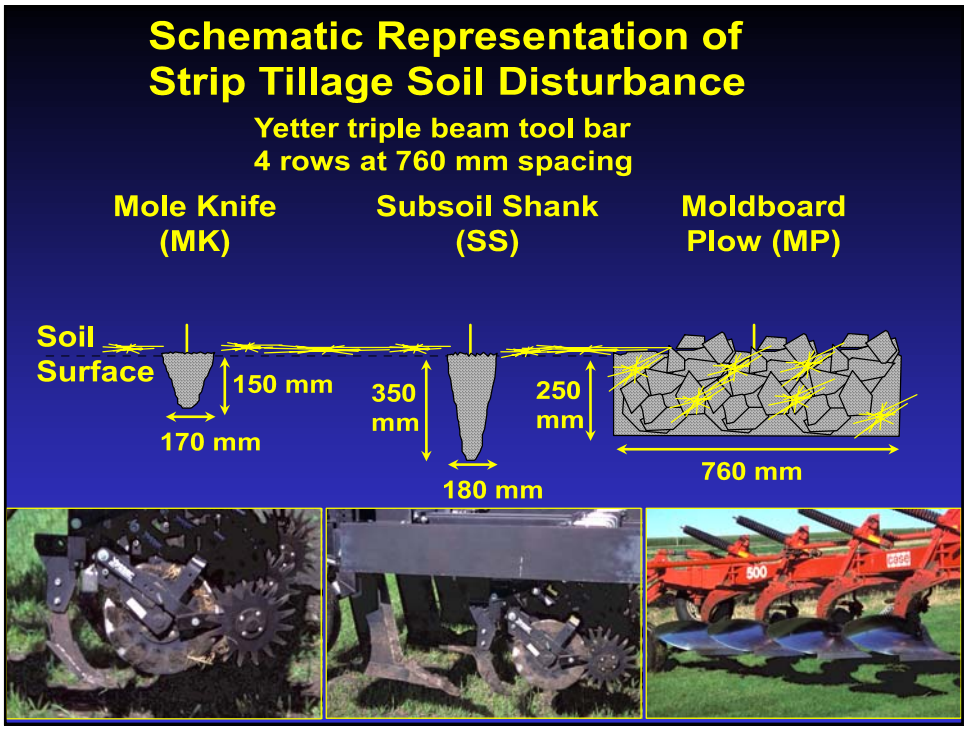
Humic fulvic acids

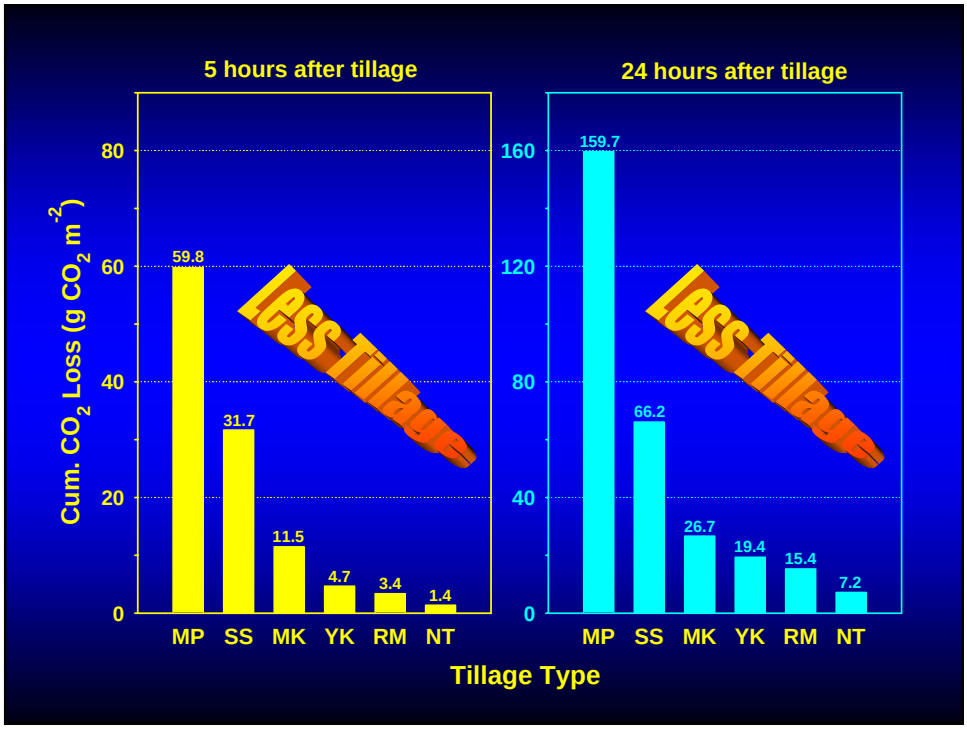
Active pools ---- Passive pools ---- Recalcitrant pools

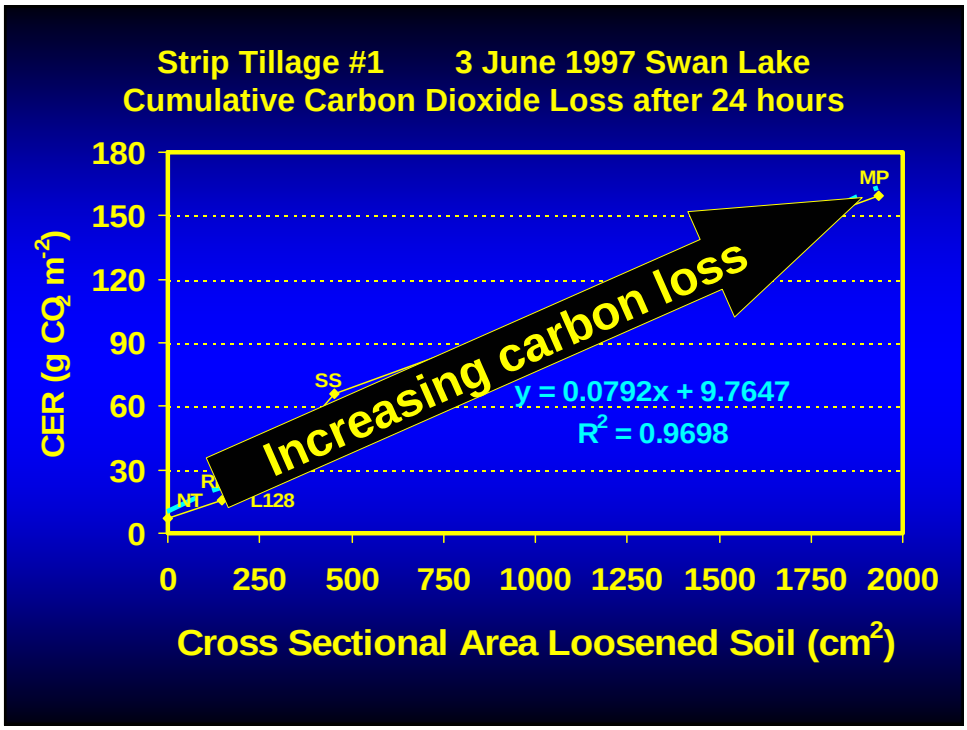


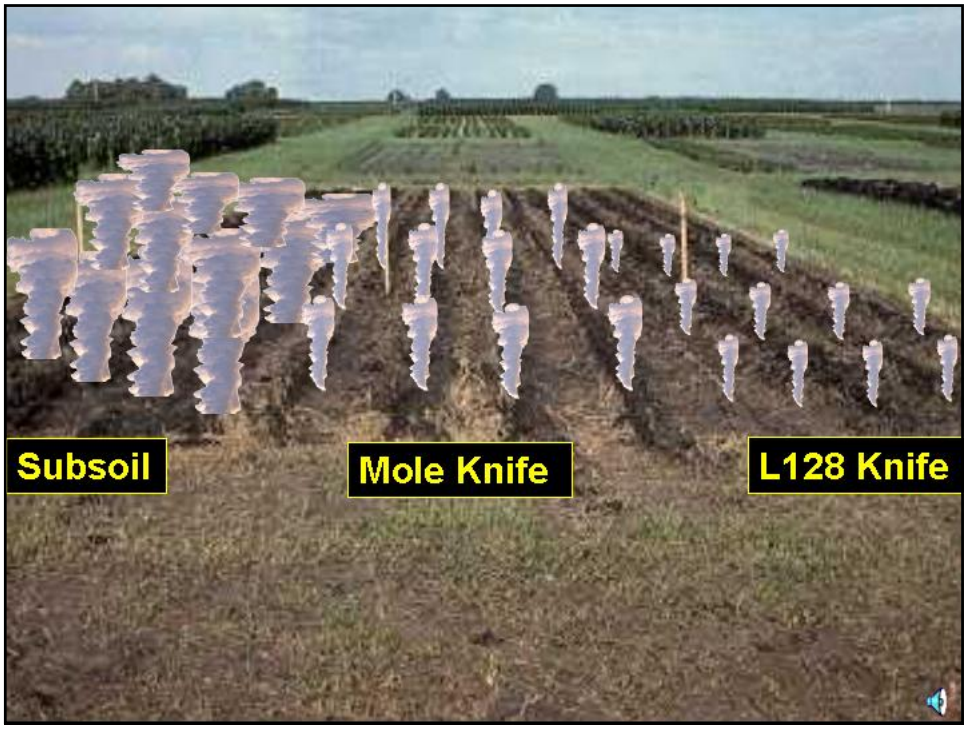


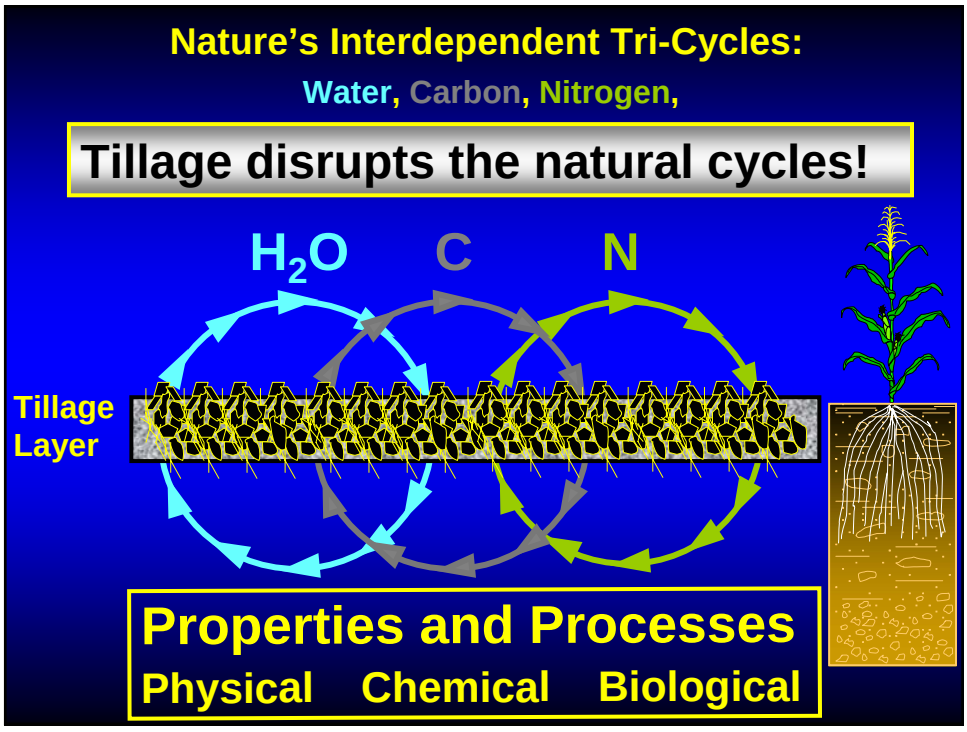


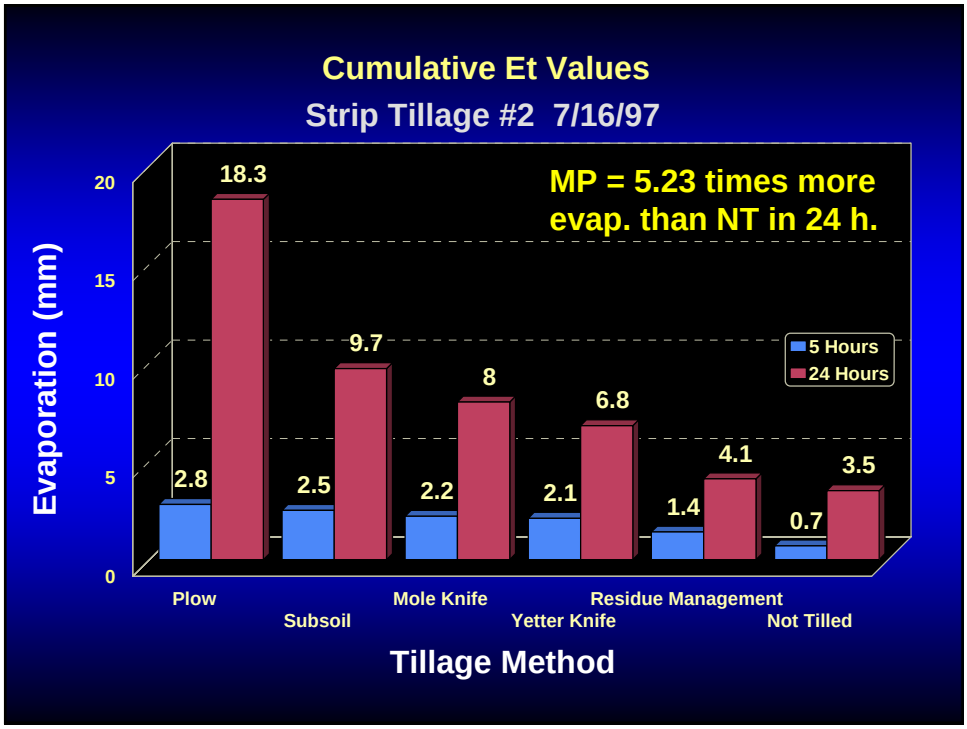


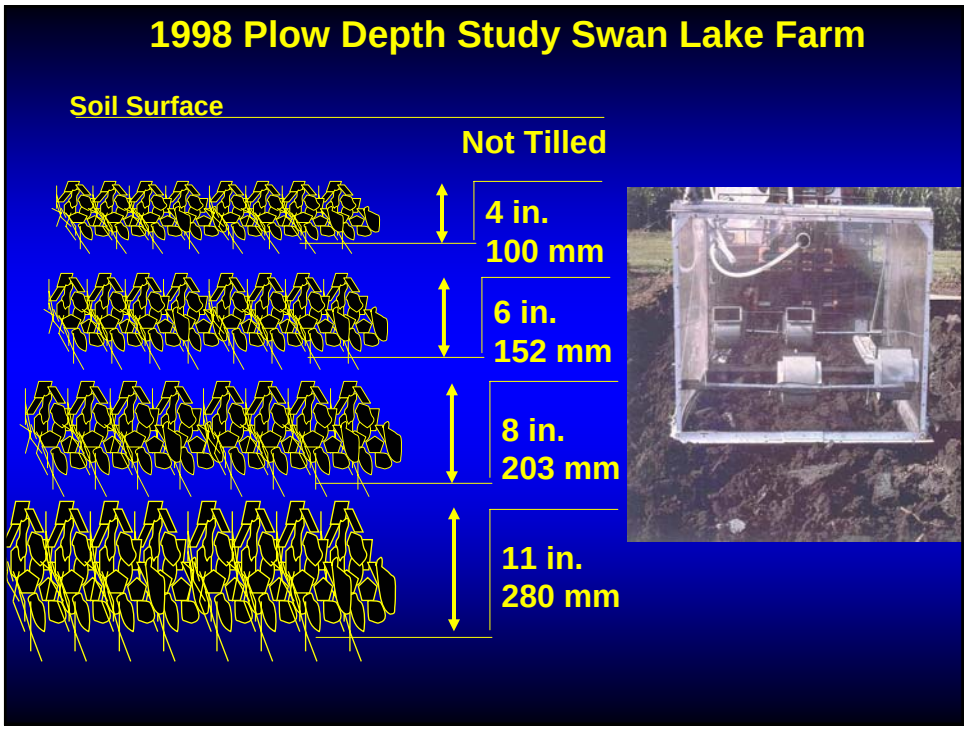


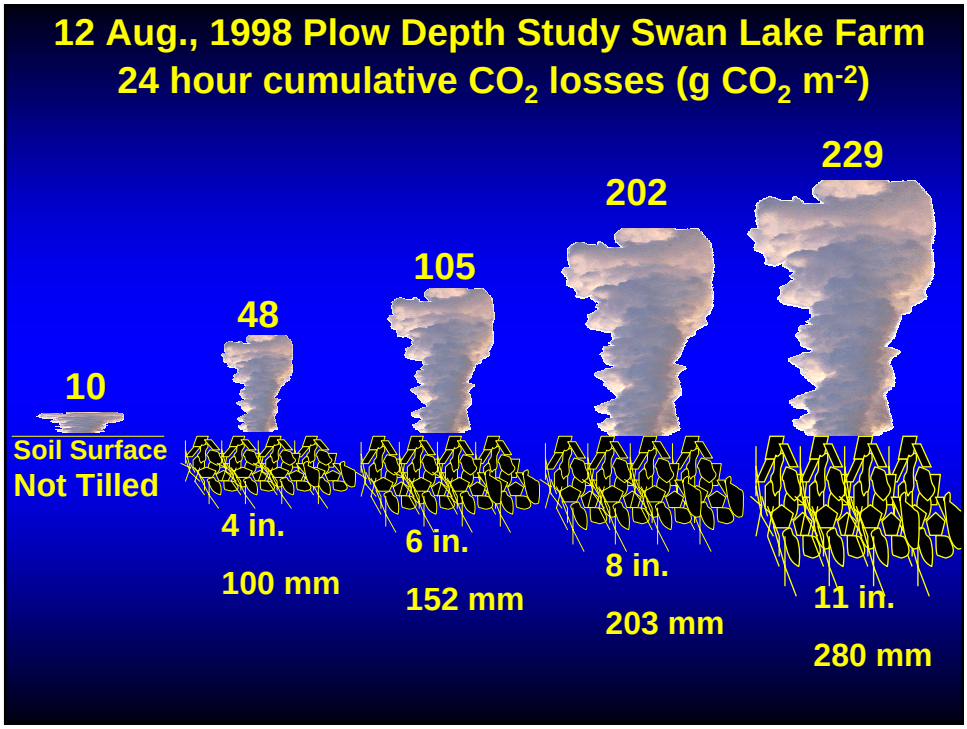












Research conclusion.

Short-term tillage-induced gas (CO_2 & H_2O) losses are directly proportional to the volume of soil disturbed in the tillage operation.

** Soil Biology Team **
The “living soil”

Earthworms, insects and rodents are the most visible components of the “living soil” team. They work in tandem either soil microorganisms and fungi to contribute to aeration and nutrient cycling as part of a “soil factory” team effort.

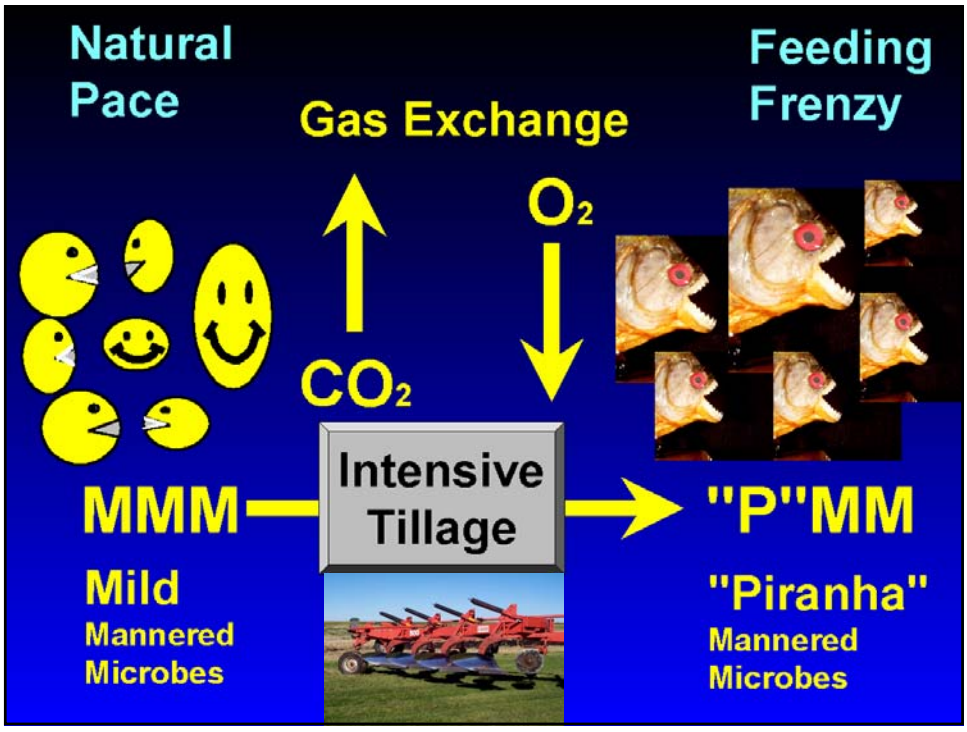
Intensive Tillage destroys the biological and ecological integrity of the soil system.

Before Primary Tillage

After Primary Tillage

After Secondary Tillage

Intensive soil tillage opens the "all you can eat buffet" for the birds and microbes.

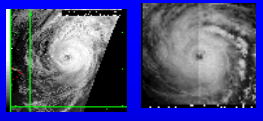


"Turmoil of Tillage"

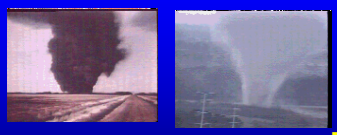
The soil is a natural biological system that contains a lot of life and when tilled intensively is dramatically changed. It can be considered analogous to human reaction to a combination of:

- earthquake

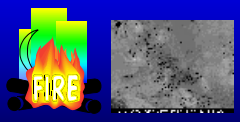
- hurricane



- tornado

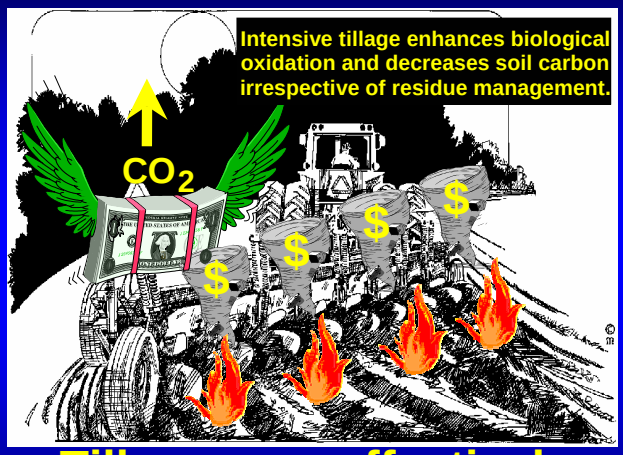


- forest fire

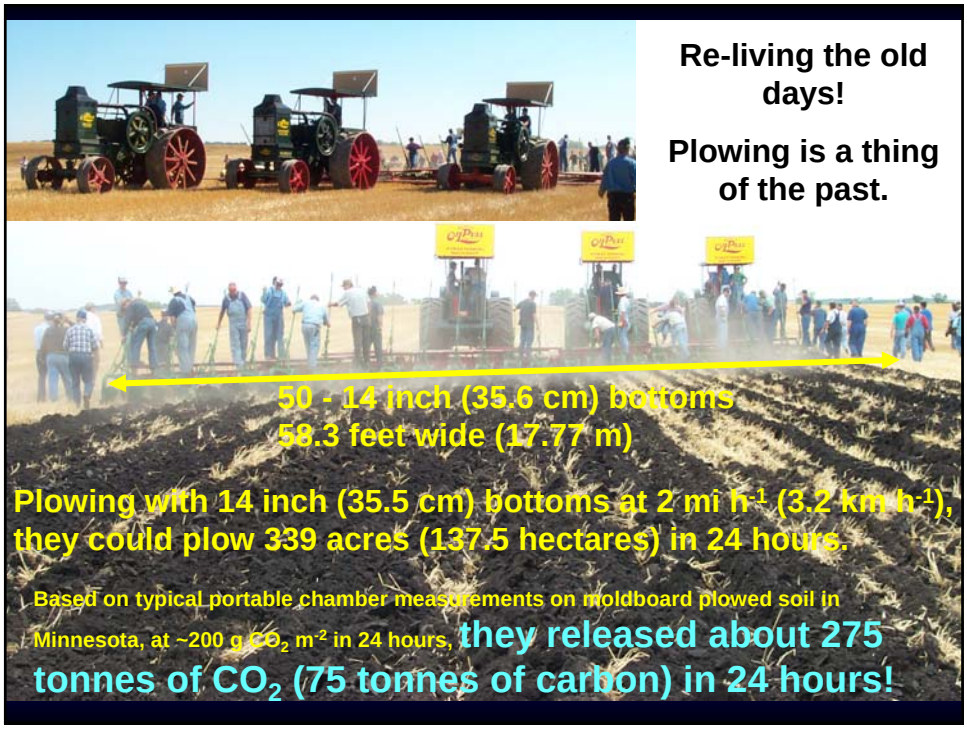


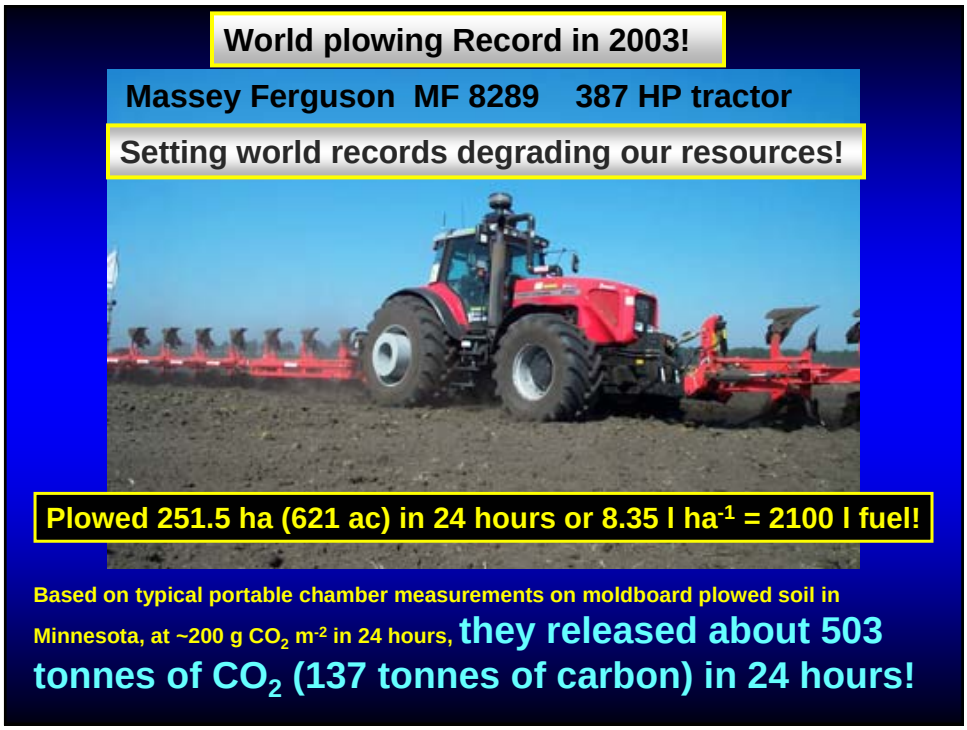
all rolled into one perturbation event.

Invisible effects of invisible forces!



Tillage very effectively facilitates biochemical degradation of organic matter.





The official WORLD GUINNESS Crop Seeding Record

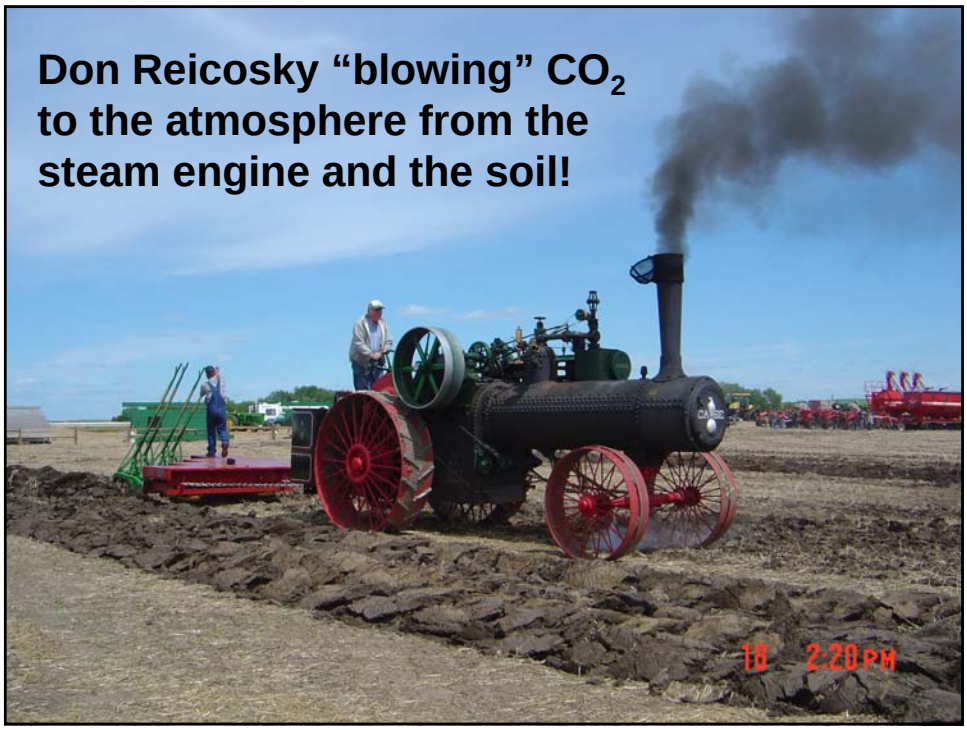
The official WORLD GUINNESS Record established on Thursday, April 24th, 2003 in the village of Majskoye in the Dnipropetrovsk Region of UKRAINE:

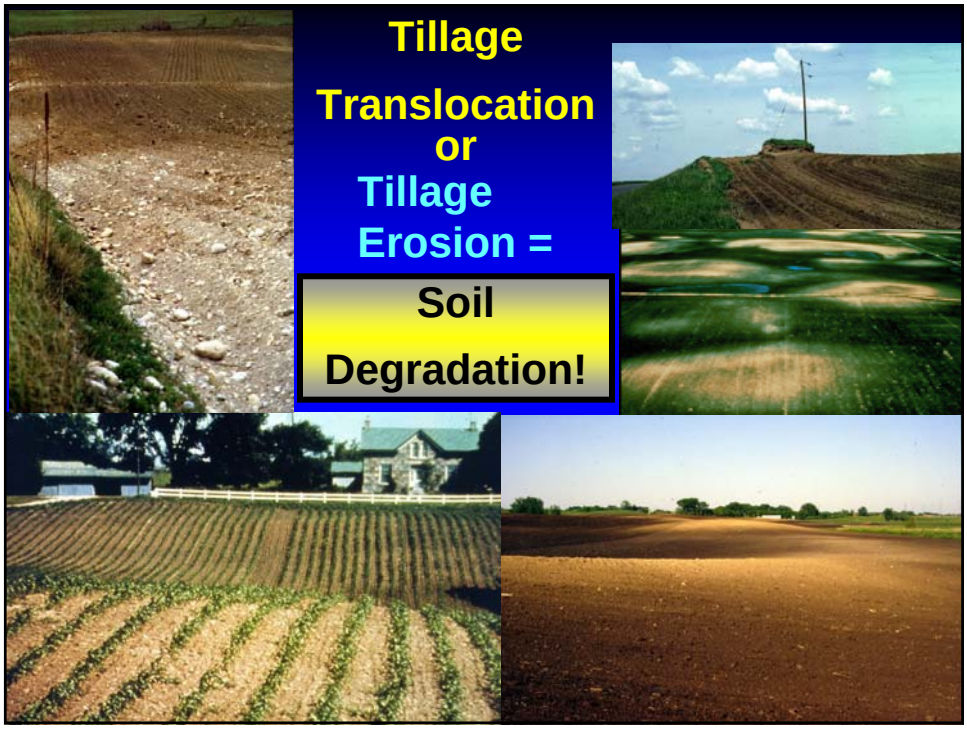
Field area on Agro-Soyuz Corporation farm in conservation tillage seeded to barley and fertilized within a 24 hour period: 571.9 hectares (1,412.59 acres).

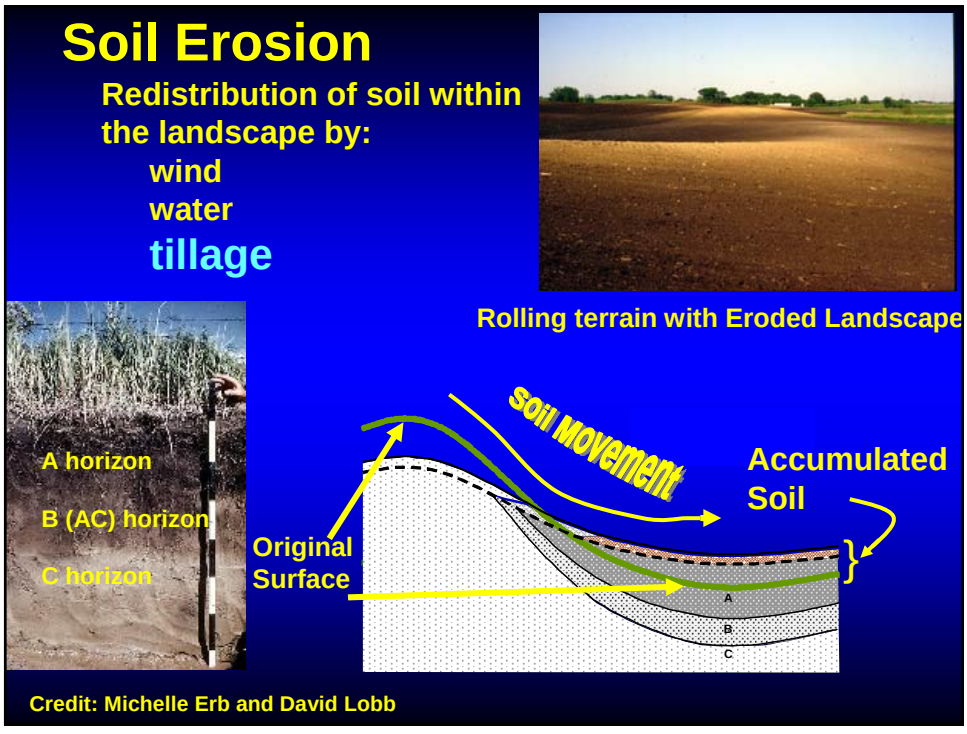
572 ha in 24 h
@ 3.84 l ha^{-1}
= 2196 l fuel.

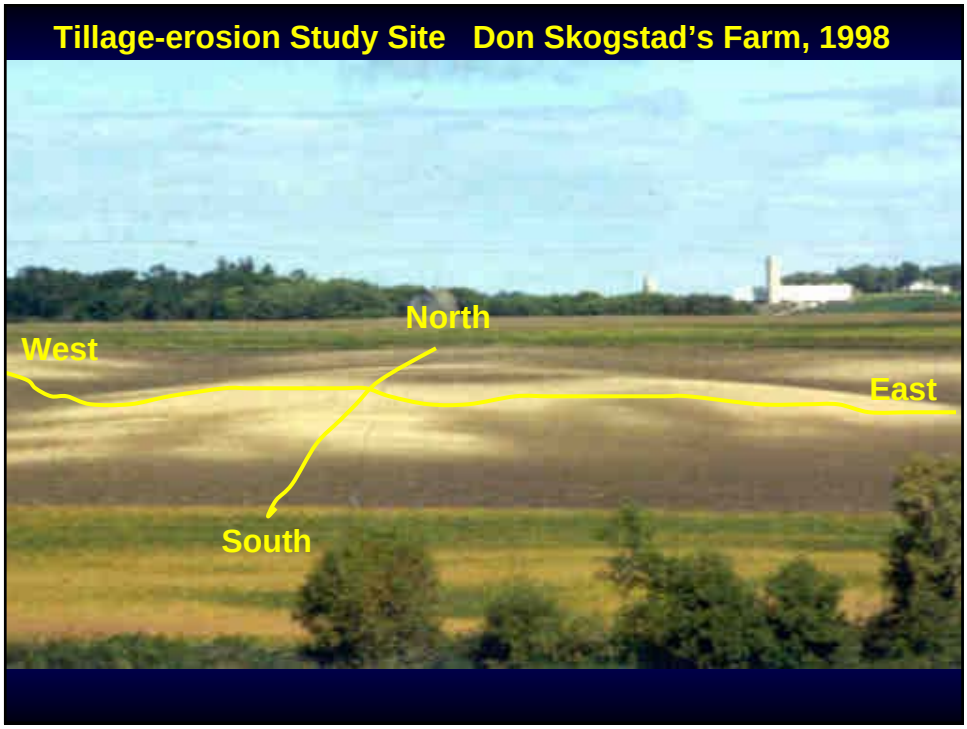
Setting world records for protecting our resources!

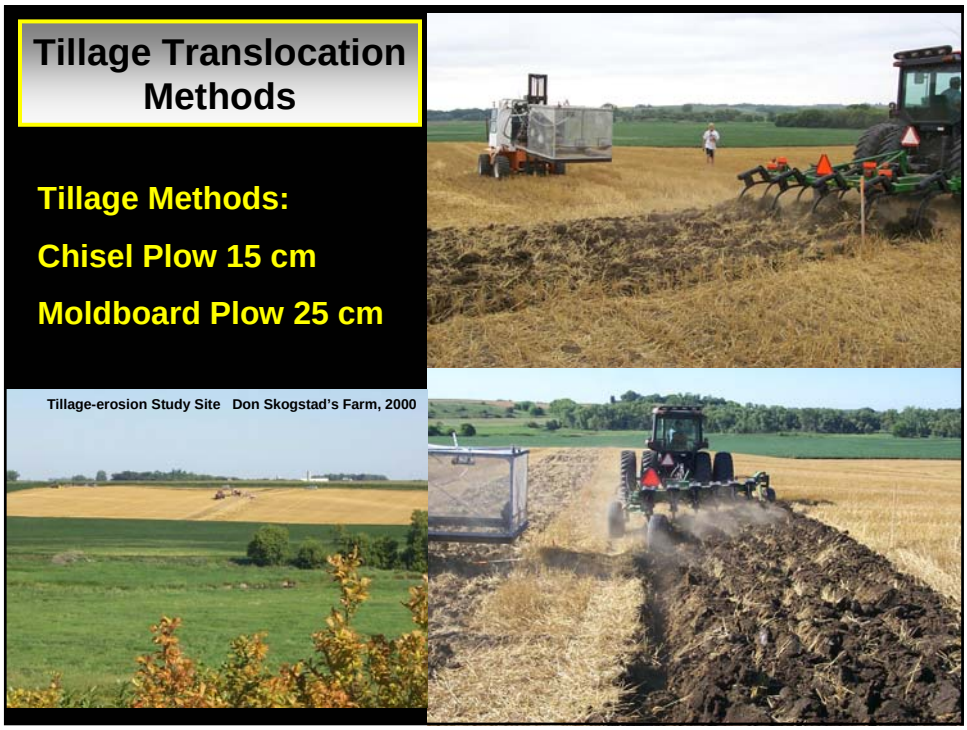
Don Reicosky "blowing" CO_2 to the atmosphere from the steam engine and the soil!

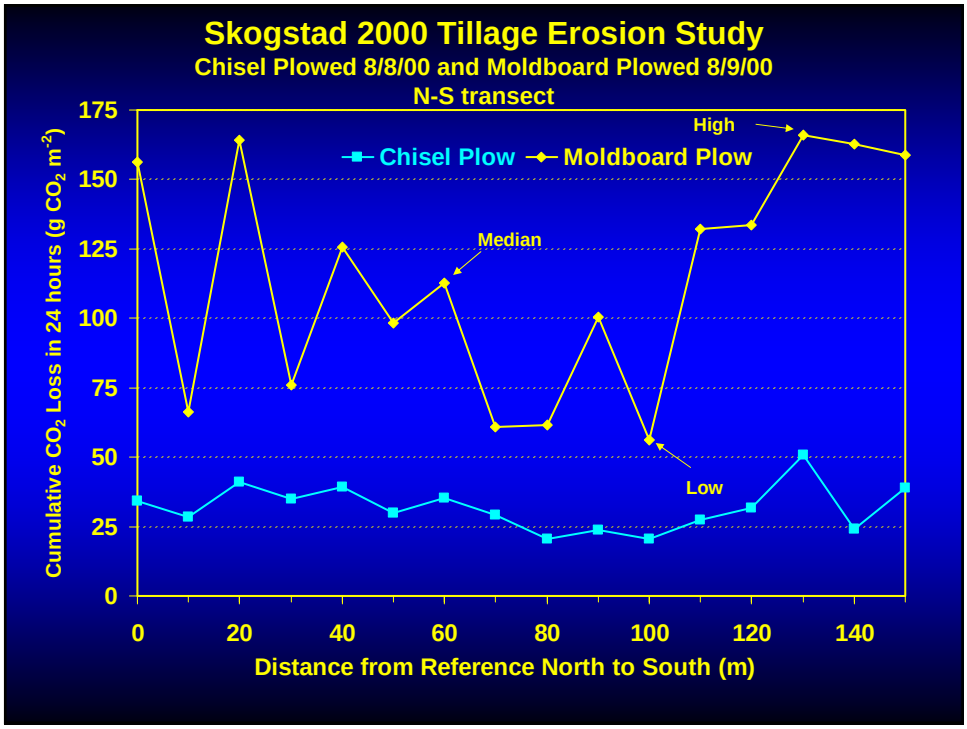


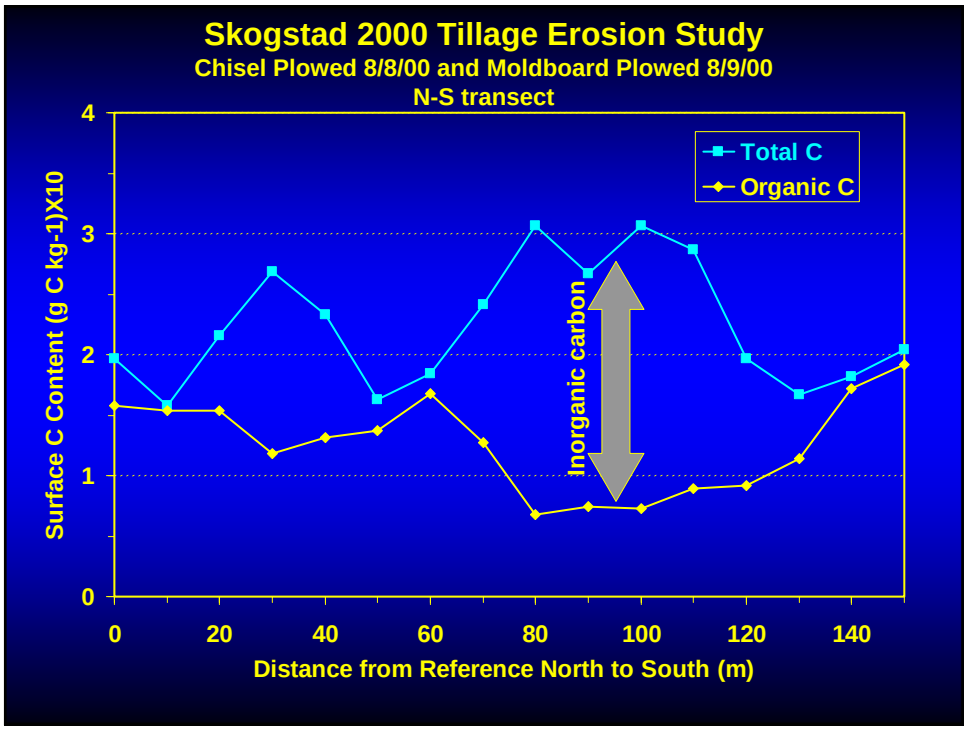


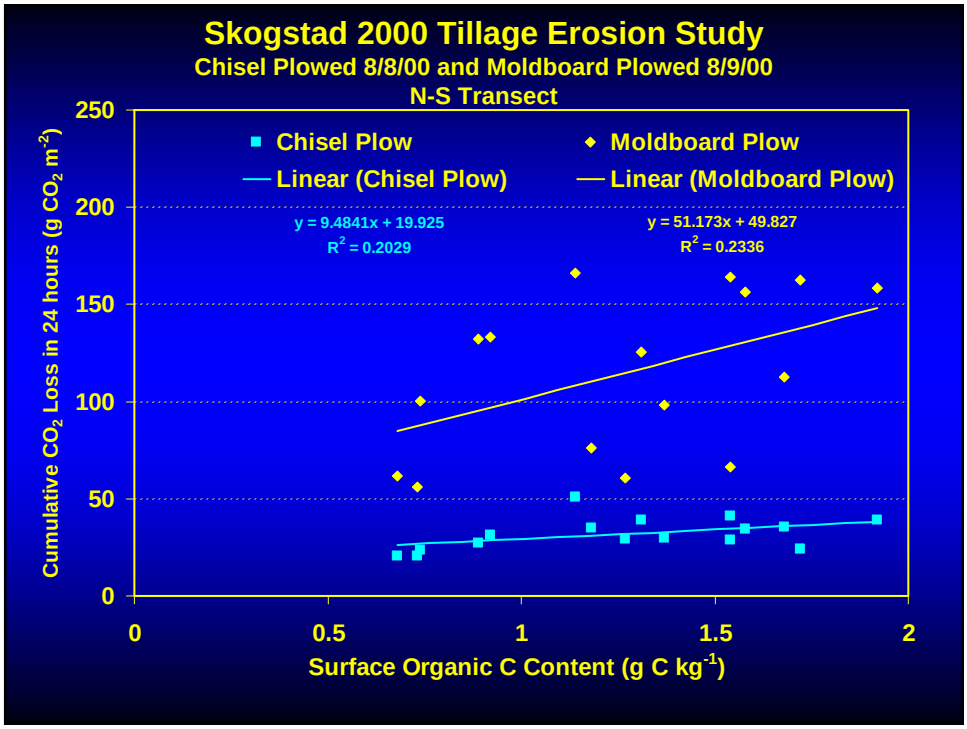








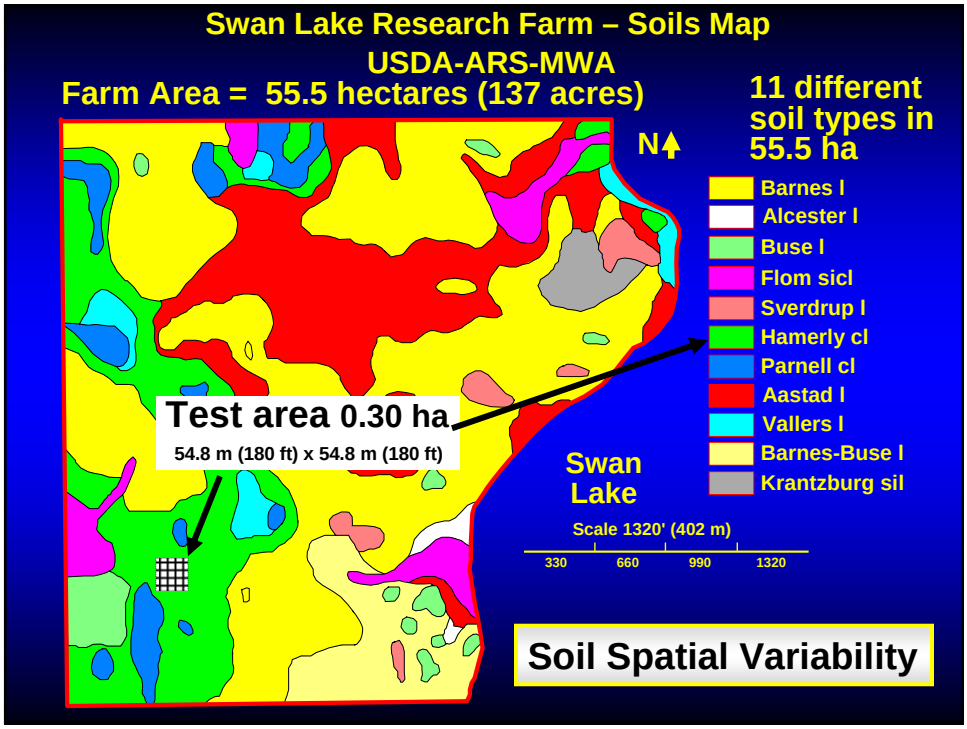


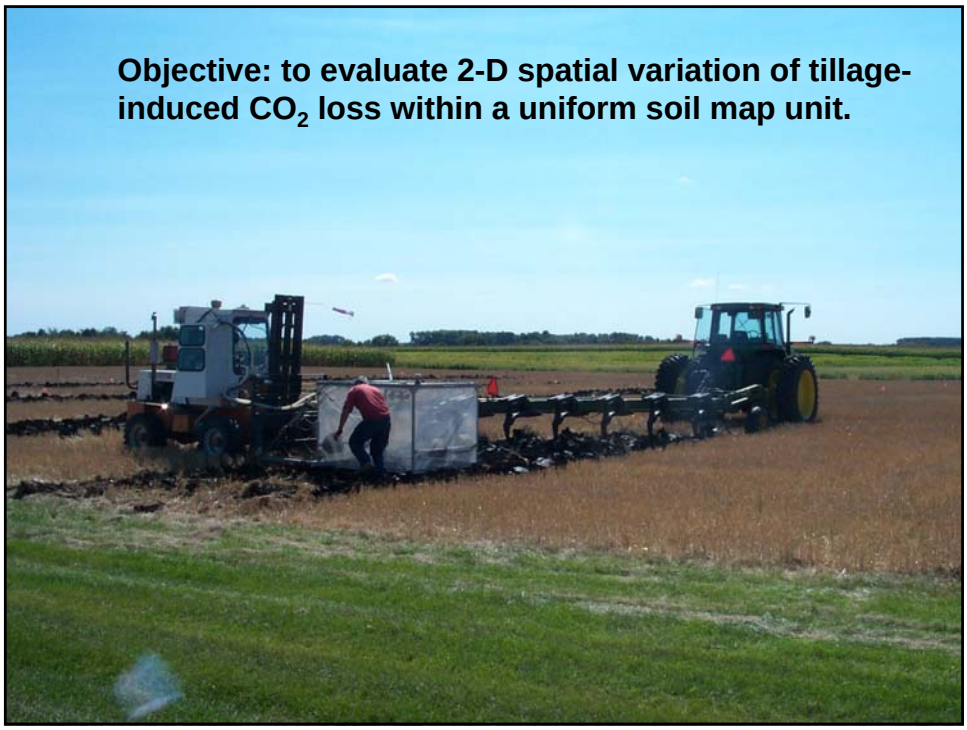


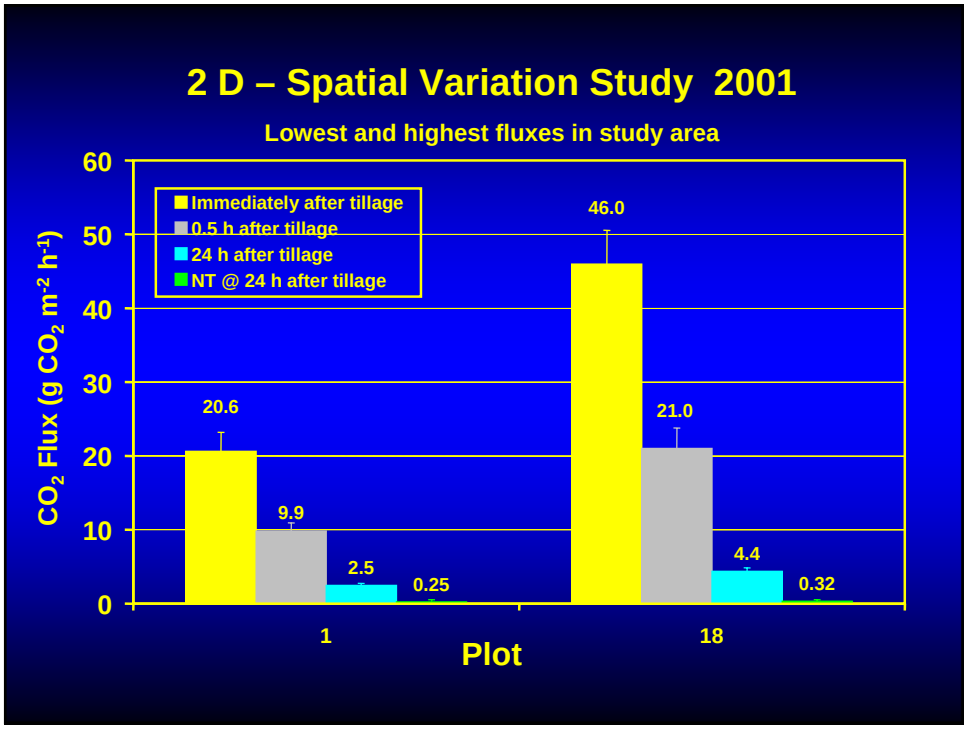
Research conclusion.

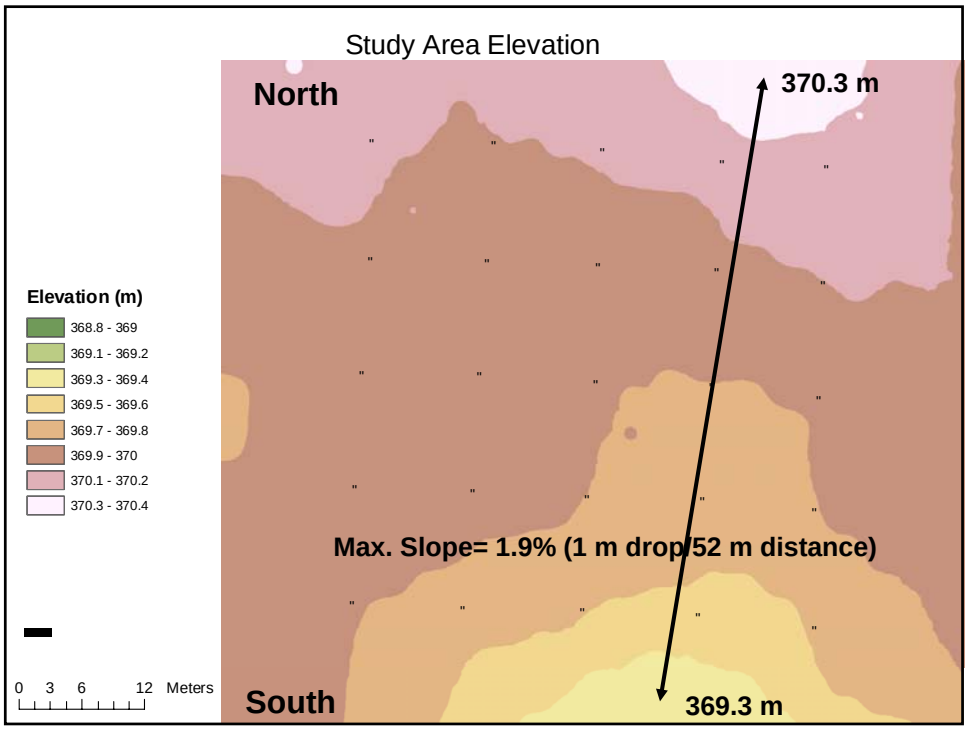
Impacts of tillage and water erosion

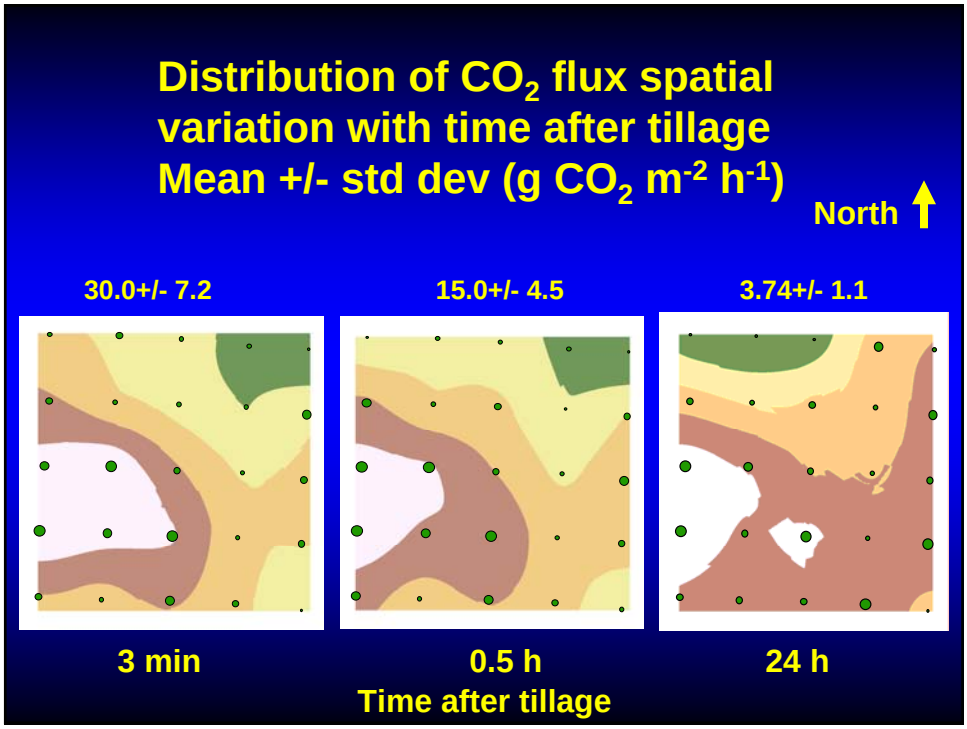
- Loss of topsoil in eroded areas
- Decreased soil organic carbon
- Lower available water and nutrient holding capacity
- Decreased soil health and reduced yield
- Increased spatial variability
- More management skills and equipment required











Research conclusion.

Spatial variation of tillage-induced gas (CO_2 & H_2O) losses within a relatively level and uniform soil type can vary as much as two-fold.

Soil Subsidence of 155 cm in 60 years without tillage or ~2.5 cm yr^{-1}.

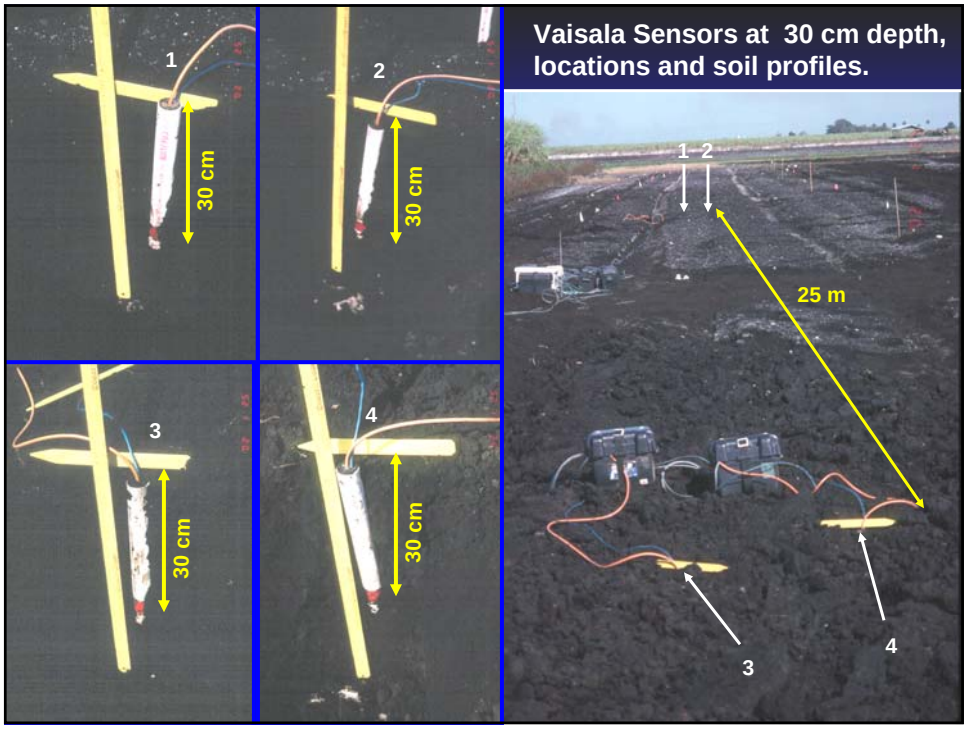
General Objective:

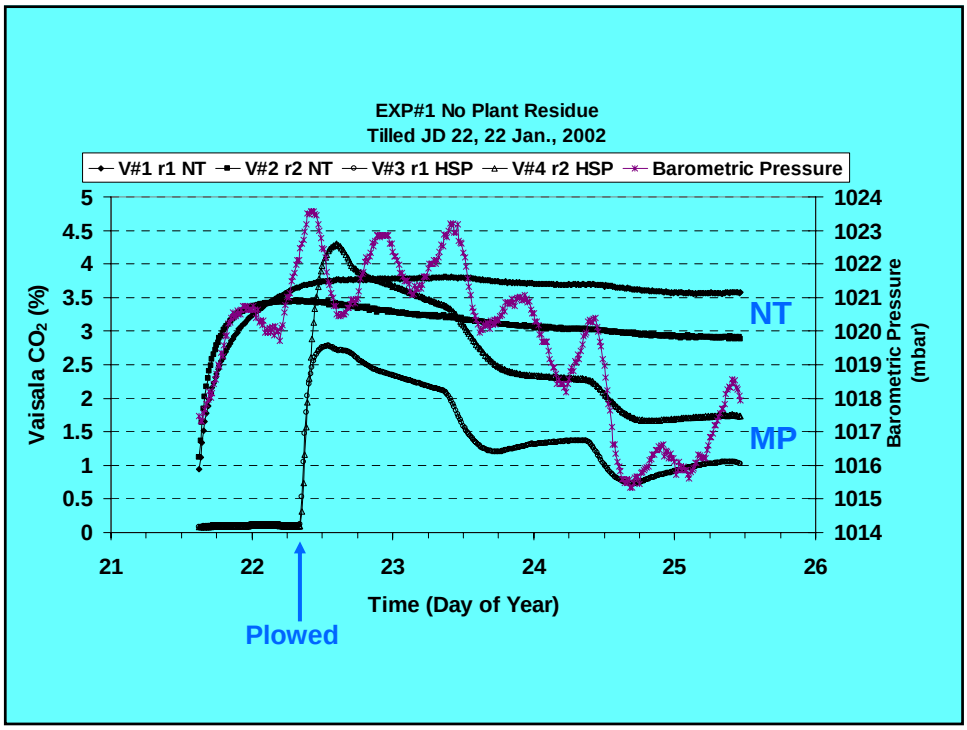
to understand tillage effects on soil subsidence and microbial respiration in organic soils.

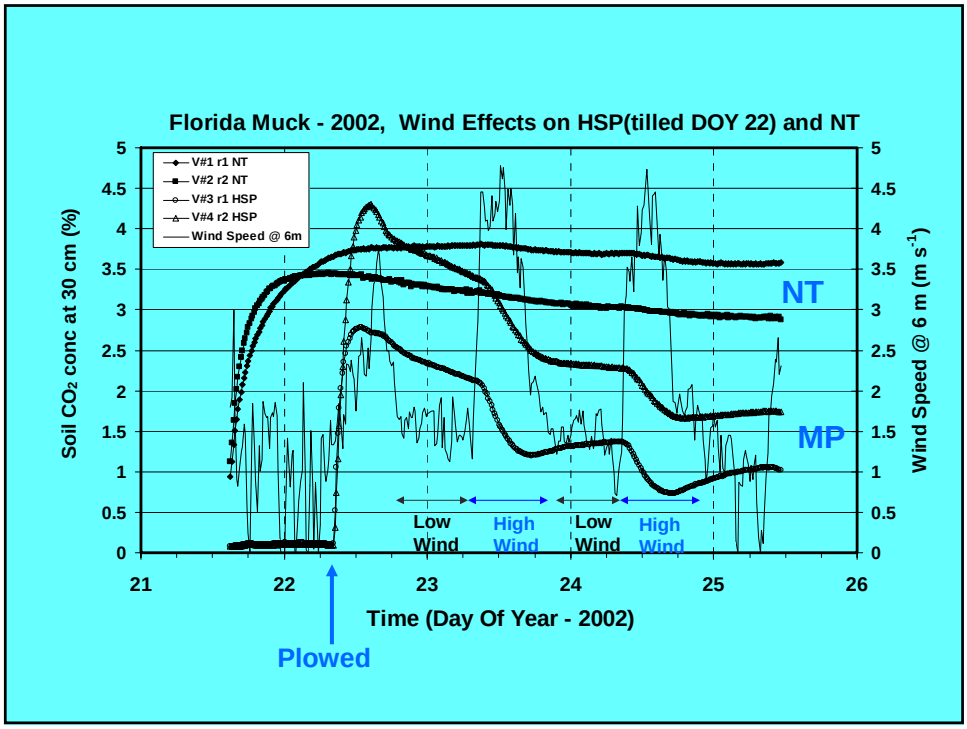
Specific Objective:

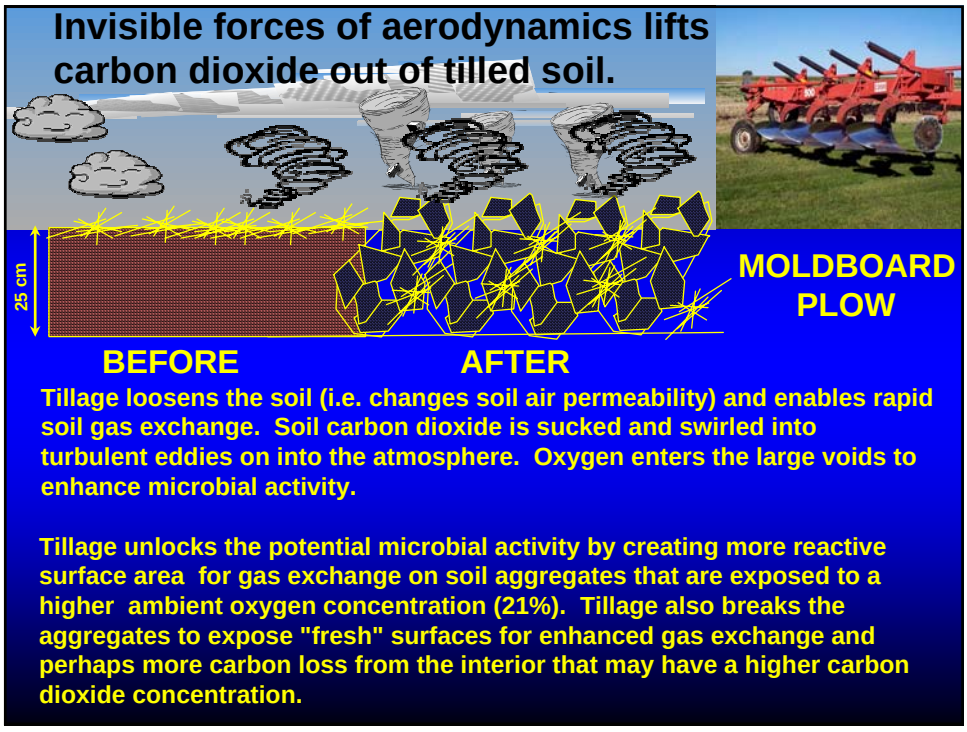
to determine the effect of no-tillage, deep plowing and wind speed on soil CO_2 concentrations in peat or muck soils that are 90% organic matter.

Tillage and Wind effects on soil CO_2 concentration.



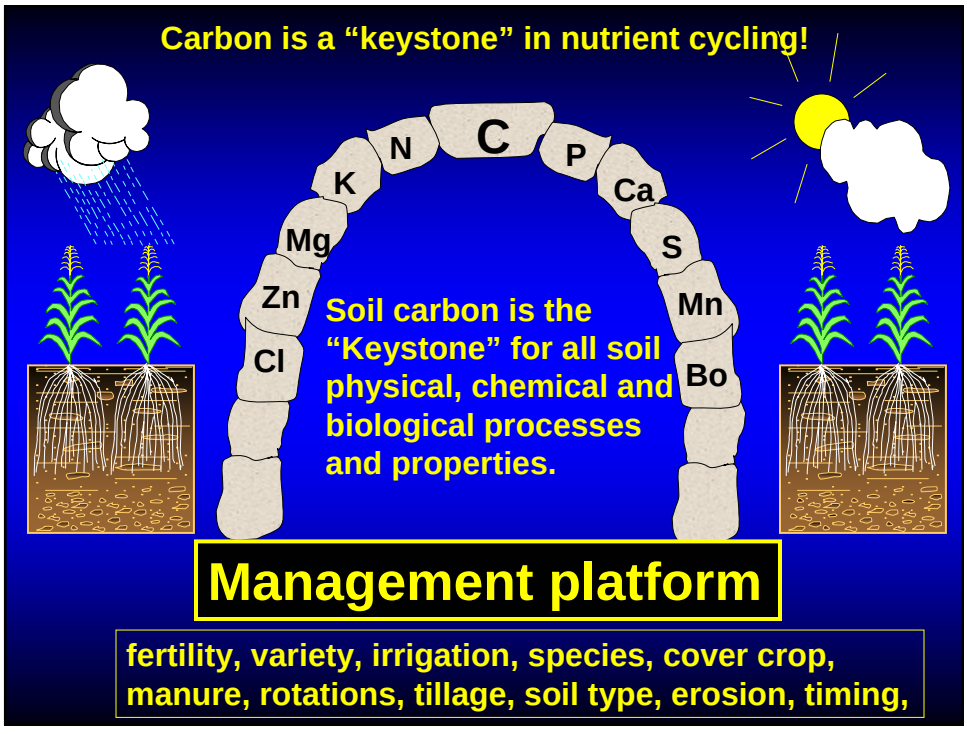


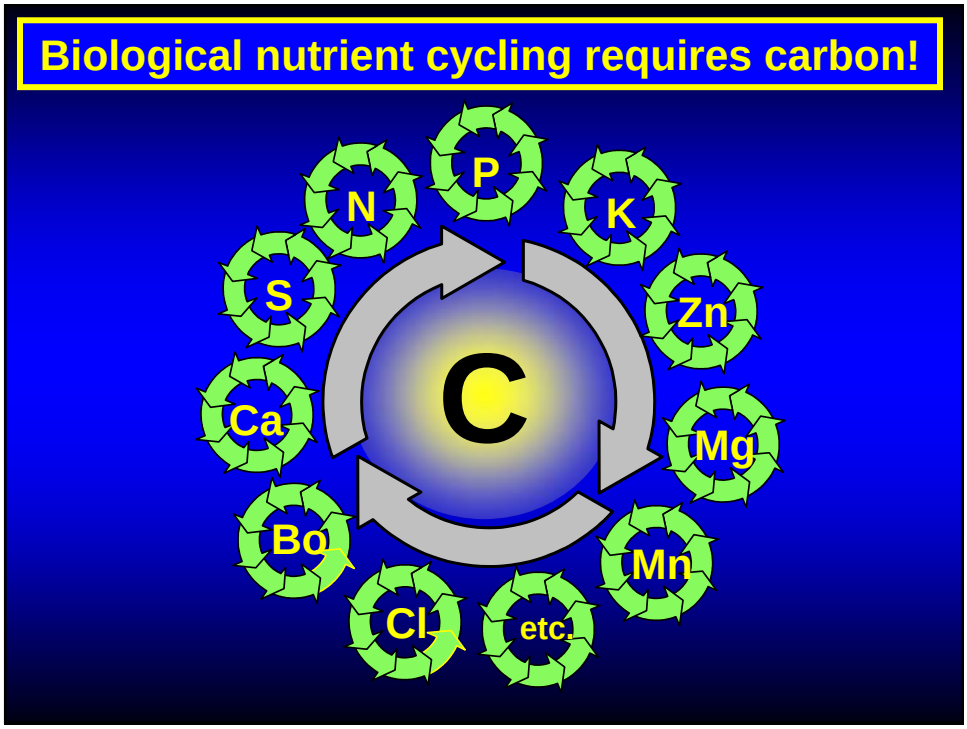


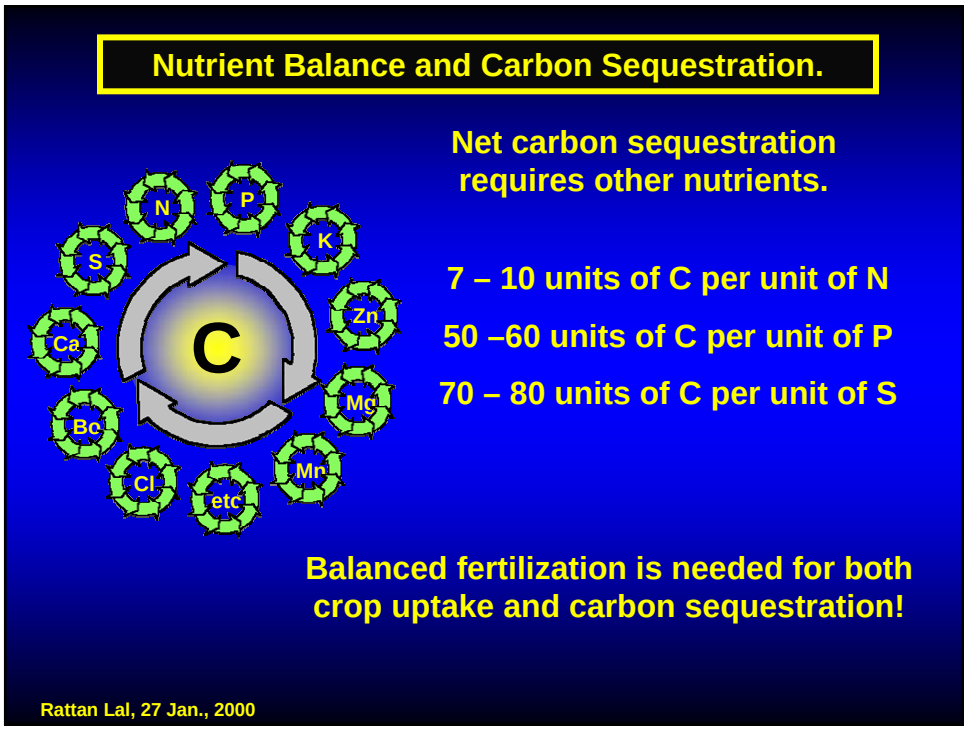


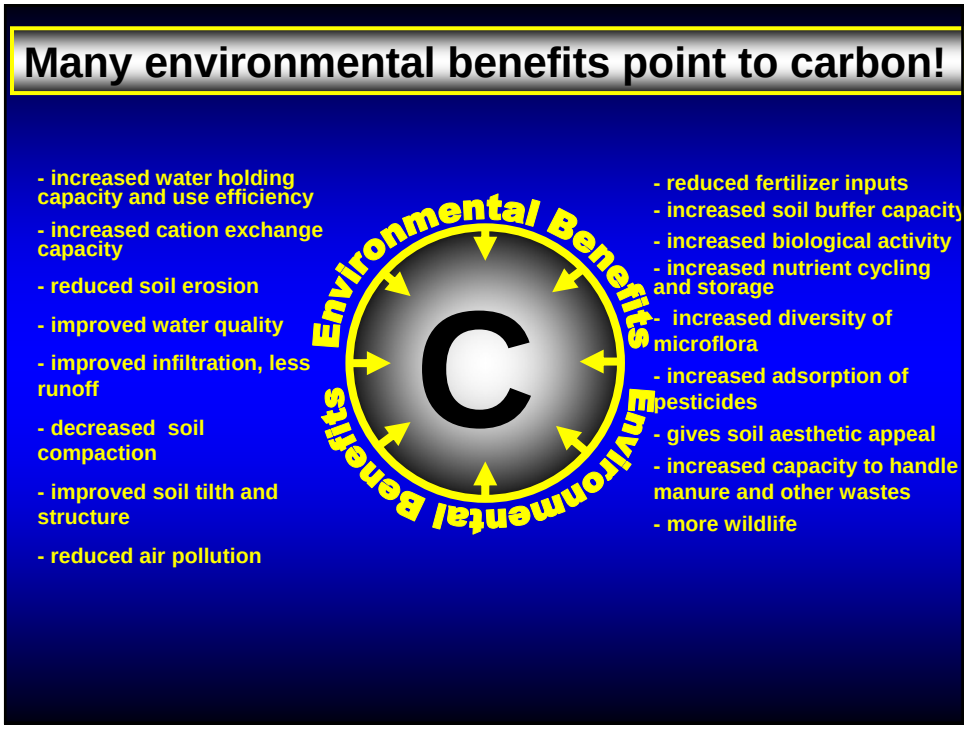
Research conclusion.

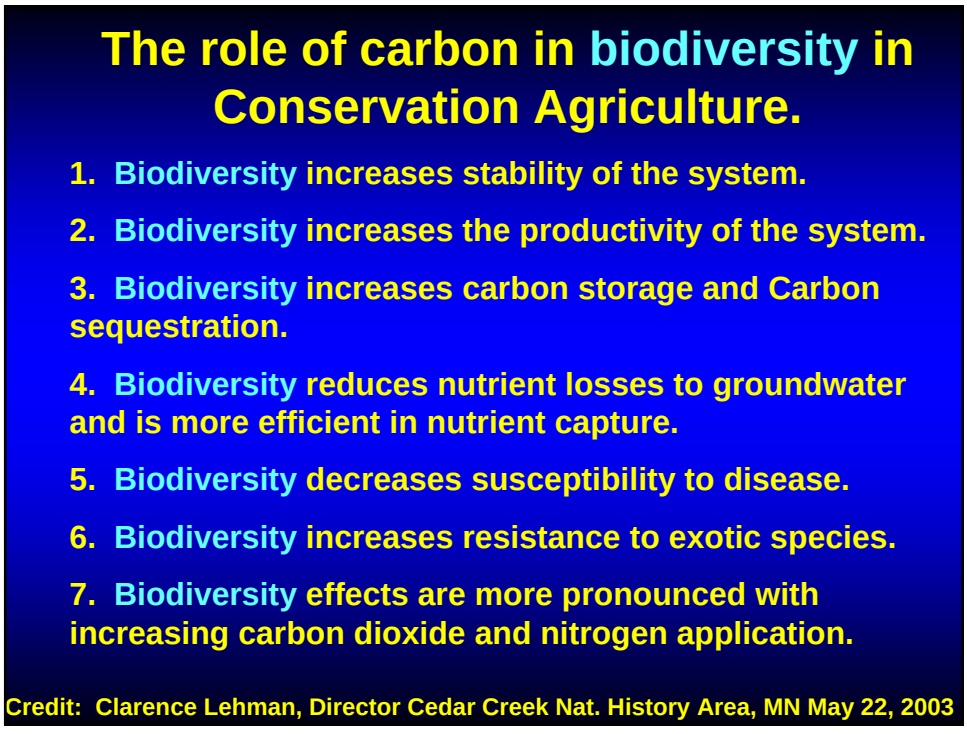
Short-term tillage-induced gas (CO_2 & H_2O) losses are related to natural wind and pressure affects.











Best for carbon input!

Simple rotations with high yields
Cover crops
Alternate crops
New bio-fuel crops
Compound rotations
Complex rotations
Simple with Perennial rotations
Stacked rotations

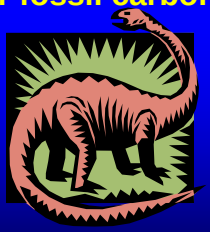
The devil is in the details!
Beckism #101

Diversification

Atmospheric Carbon as CO_2

Time Frame of Carbon Cycles

Fossil carbon cycle.
Cycle time is millions of years for fossil carbon.

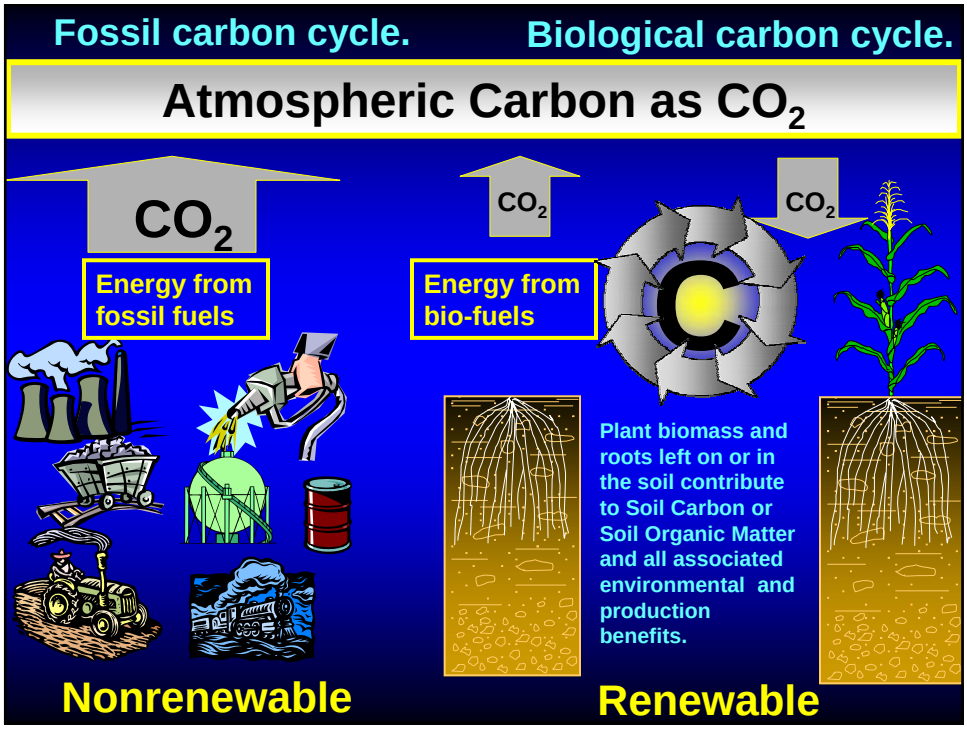


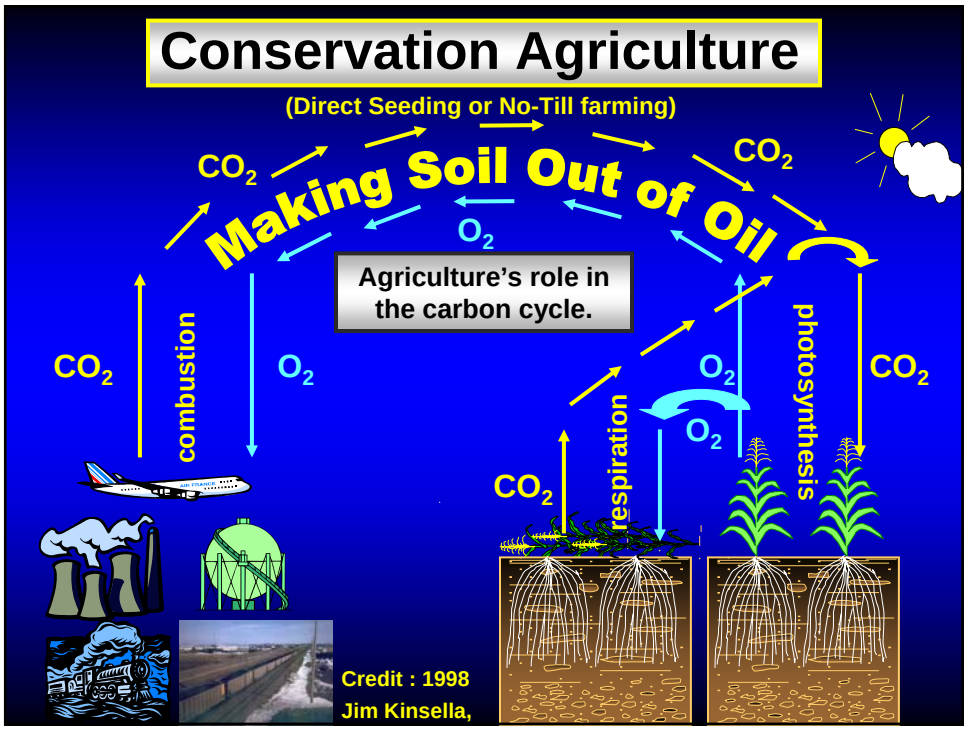
Nonrenewable

Biological carbon cycle.
Cycle time is 1 - 10 years for biological carbon.

Renewable

The major strength of biofuels is the potential to reduce net carbon dioxide emissions to the atmosphere.





Conservation Agriculture

Manage soil carbon!

"Delay Decay"

Conservation Agriculture is a Win-Win Strategy!

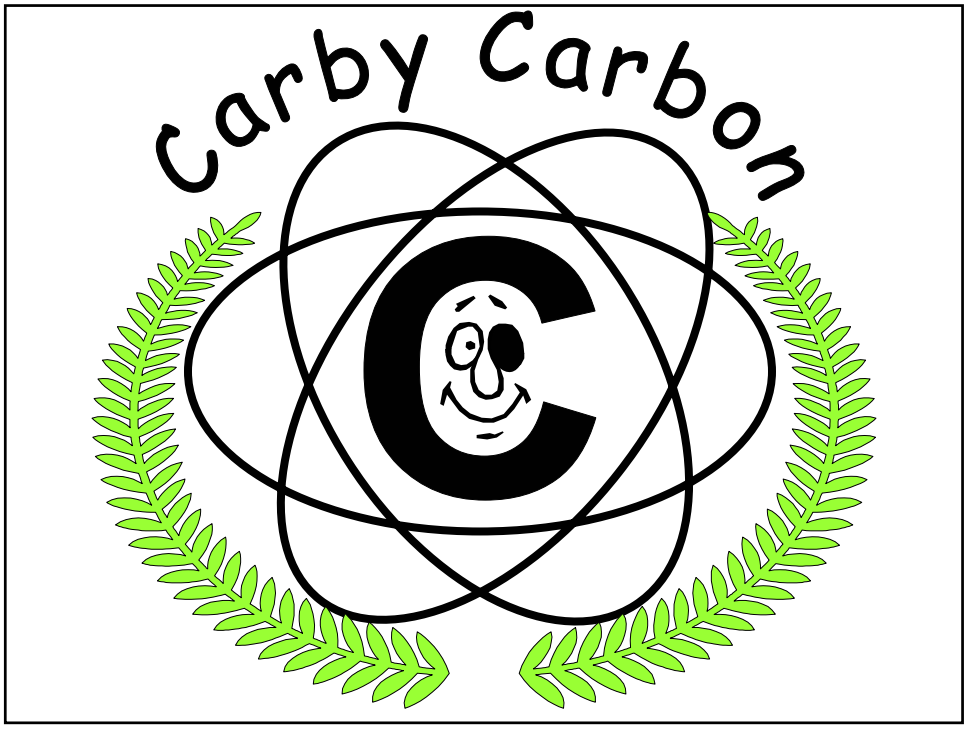
Win #1

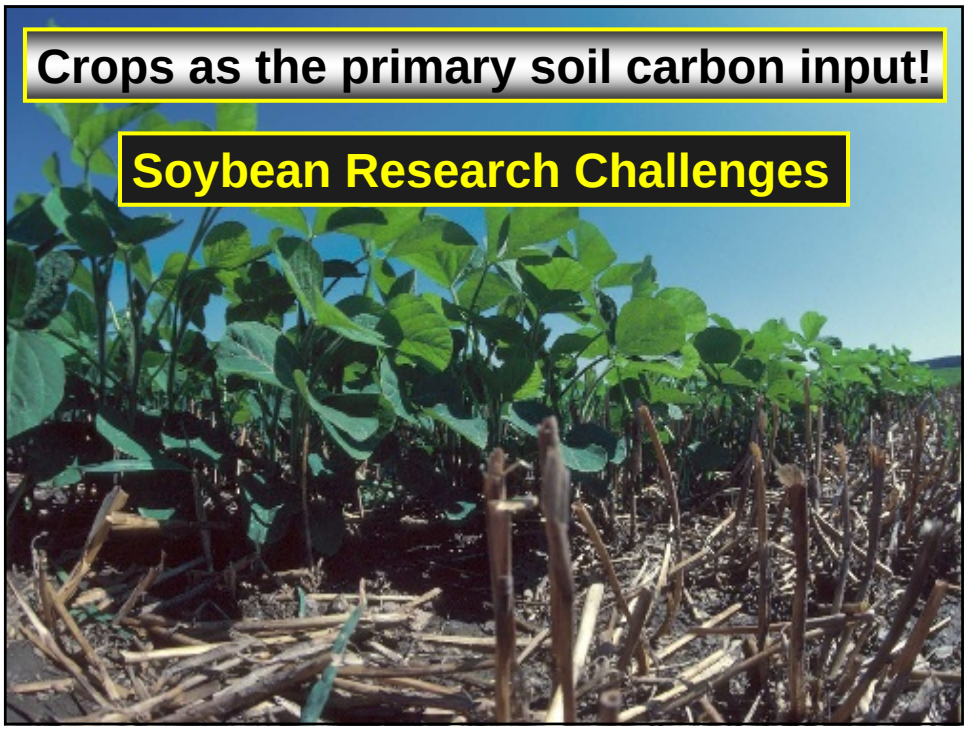
Growing food and fiber to feed the world.

Win #2

Protecting the environment and all its resources.

A lot of responsibility for farmers!





Soybean, the "Versatile" crop.

New soy based foods:

tofu, soy milk, improved oil, higher protein, more isoflavones, reduced undigestable sugars, frozen deserts, cereals, cheese, soy nuts, barbecue riblits, coffee substitute, etc., etc.

Soybean for health:

heart disease, menopause, osteoporosis, cancer(breast & prostate), kidney problems, aging etc., etc.,

Soybean for bio-fuel:

soy diesel, renewable fuel

These positive bi-products and benefits of soybean must not be offset by negative environmental impacts of soybean.

Soybean Rhizosphere effects on carbon loss

Mollisol, Konza Prairie, 2.3 %C, 0.2% N, pH=7.6

Cumulative soil-derived CO_2- C during season

	%		mg C g^{-1} soil
No plants			
0 - NPK	100		0.58
L - NPK	100	100%	0.59
H - NPK	100		0.57
Soybean			
0 - NPK	275		1.60
L - NPK	262	264%	1.60
H - NPK	256		1.35
Wheat			
0 - NPK	201		1.05
L - NPK	186	196%	1.04
H - NPK	201		1.03

Source: Cheng et al., 2003. SSSAJ 67: 1418-1427

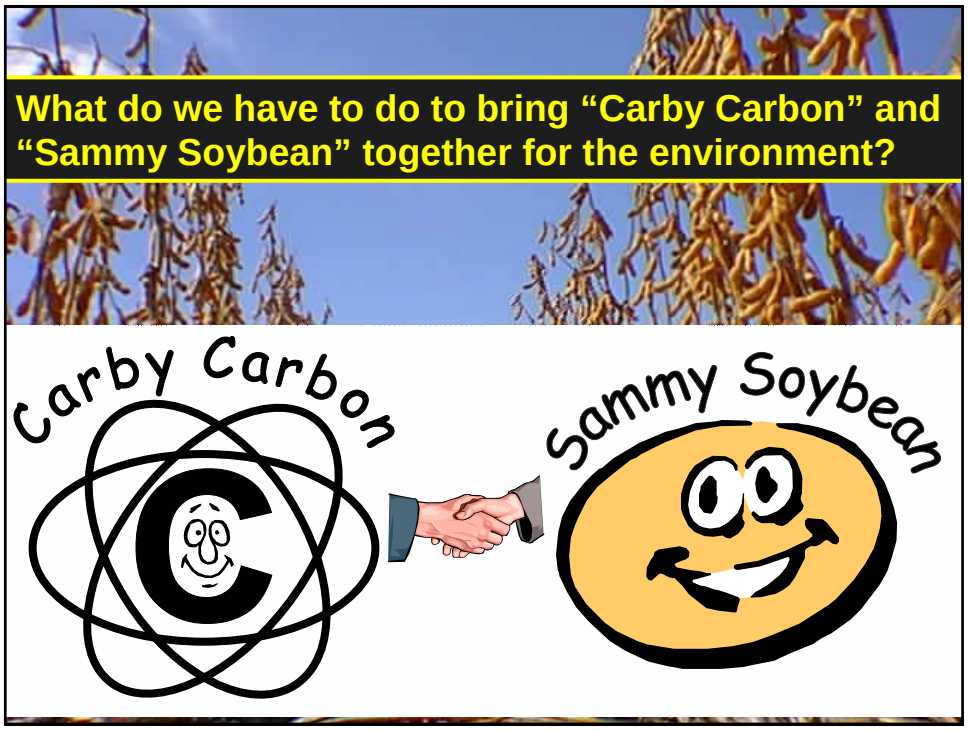
Soybean effects on current soil carbon

Change in C in top 20 cm after 13 years continuous corn and 4 years continuous soybean (g m^{-2})

	Residue returned		Residue removed	
	0 kg N ha^{-1}	200 kg N ha^{-1}	0 kg N ha^{-1}	200 kg N ha^{-1}
NT	+58	-1017	-348	-279
MP	-435	-782	-393	-430
CP	-313	-218	-258	-184

Overall relation after 13 yr of continuous corn followed by 4 yr continuous soybean suggests a 24 % decrease in SOC after soybean!

Source: Layese et al., 2002. Soil Sci. 167(5): 315-326.

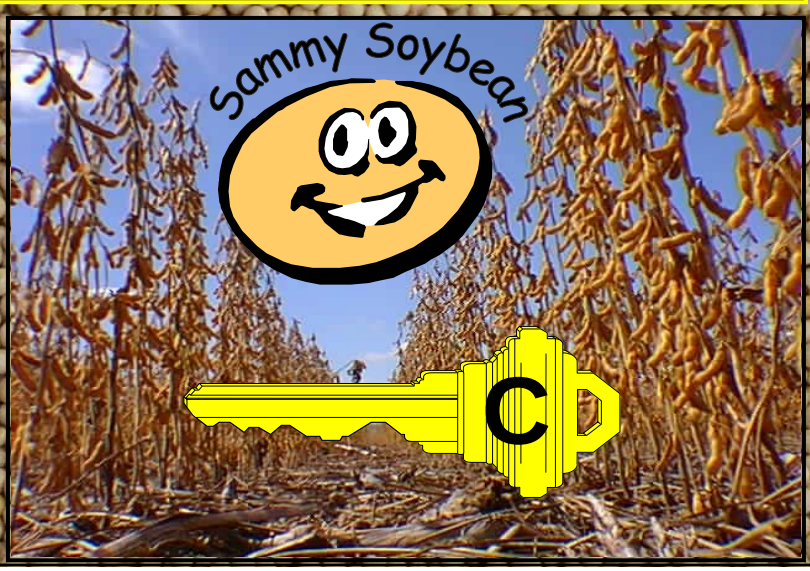


What can we do to improve soybean and soil carbon relationships?

- Increase grain yield,oil and protein content
- Increase root and above ground biomass
- Increase resistance to pests and disease
- Increase Nitrogen fixation capacity
- Decrease Shoot:root ratio
- Increase C:N ratio and resistance to decomposition
- Develop soybean as renewable biofuel
- Use direct seeding techniques with cover crops
- Use diverse rotations in Conservation Agriculture

Ask not what soybean production can do for you.

Ask what you can do to make soybean production sustainable.



Research conclusion.

Soil carbon management in soybean production is very challenging and requires more diverse crop rotations and/or cover crops to be a sustainable system.