Growing MI Agriculture Conference

Lansing, MI 24 Jan., 2013

Managing soil to improve infiltration and water holding capacity: Carbon management.

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The Global Crises

Financial

Terrorism

Food security

Energy Supply

Health Equity

Environmental Degradation

Climate Change

Our good earth

The future rests on the thin layer of soil beneath our feet

There is pressure on our earth resources and food security!

9,000,000,000 people by 2050

1,440,000,000 ha cropland
(3.56 billion acres)

We are "sandwiched" in a very fragile system!

Very thin, fragile atmosphere.

7,018,456,957 people

Very thin, fragile soil.

Carbon is Critical!

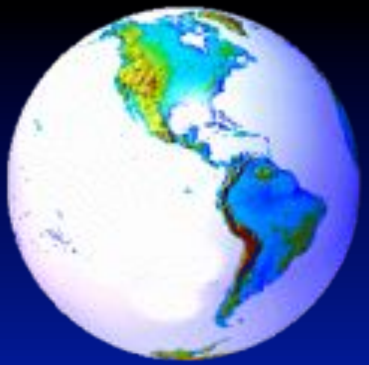
OUR HUNGRY WORLD

OUR THREATENED PLANET

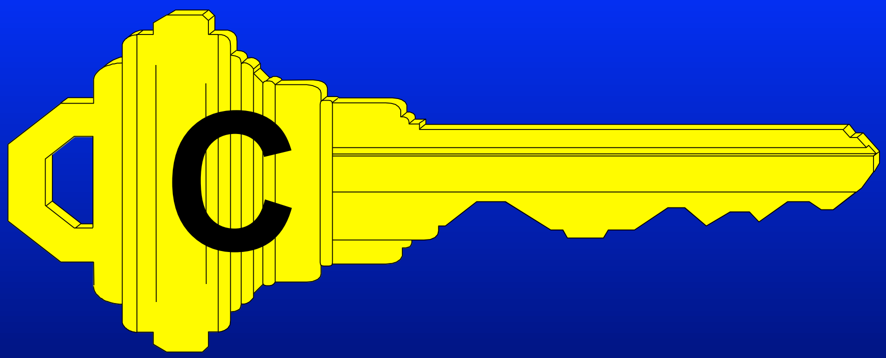
OUR CHILDREN' S FUTURE

OUR ONE CHANCE… Conservation Agriculture

All rest on "OUR LIVING SOIL" that depends on soil carbon!



The "key" component is:



c a r b o n !

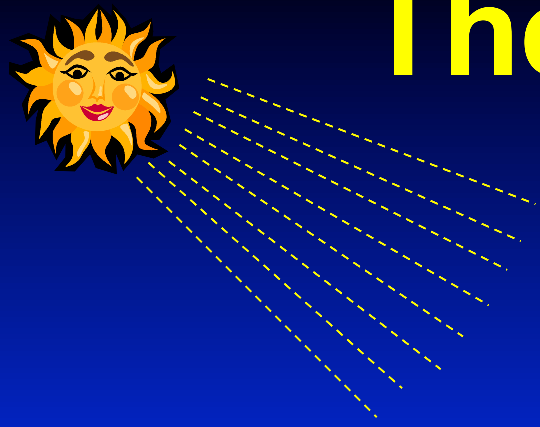
Photo Source: NASA

3 Keys to Conservation Agriculture!

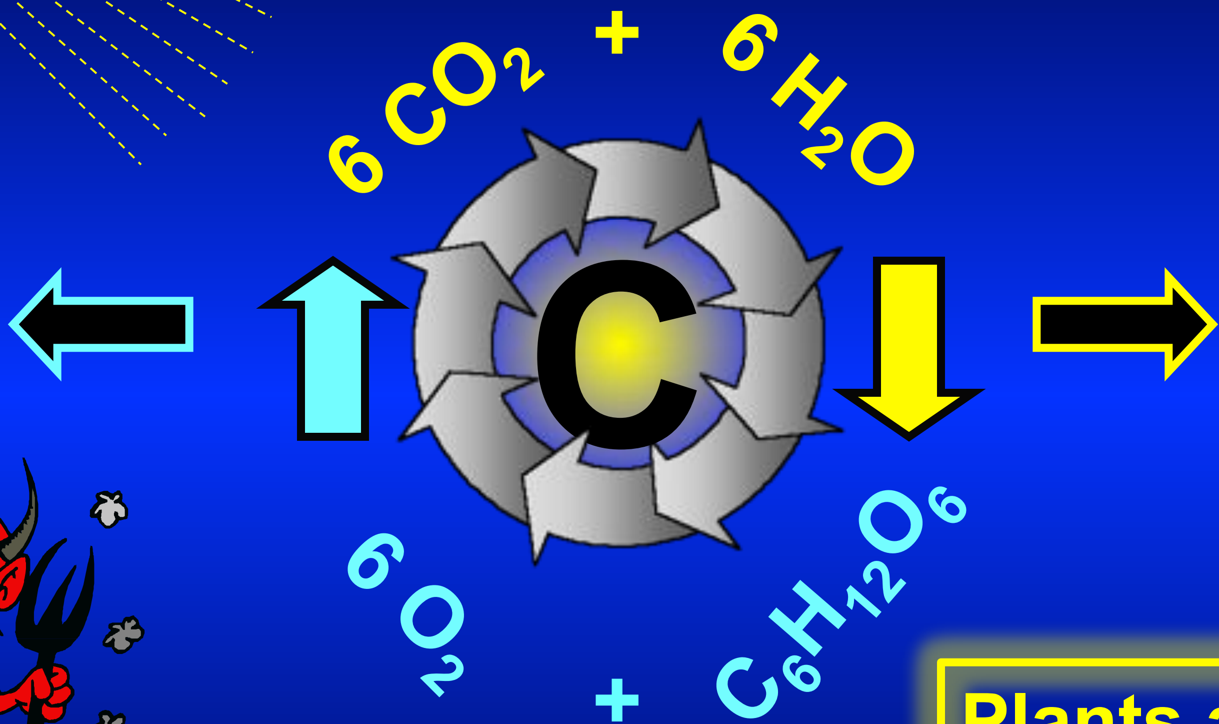
1. Minimal soil disturbance
2. Continuous residue cover
3. Diverse rotations and/or cover crops

Soil Organic Carbon

The Carbon Cycle



Photosynthesis



Respiration

The devil is in the details!

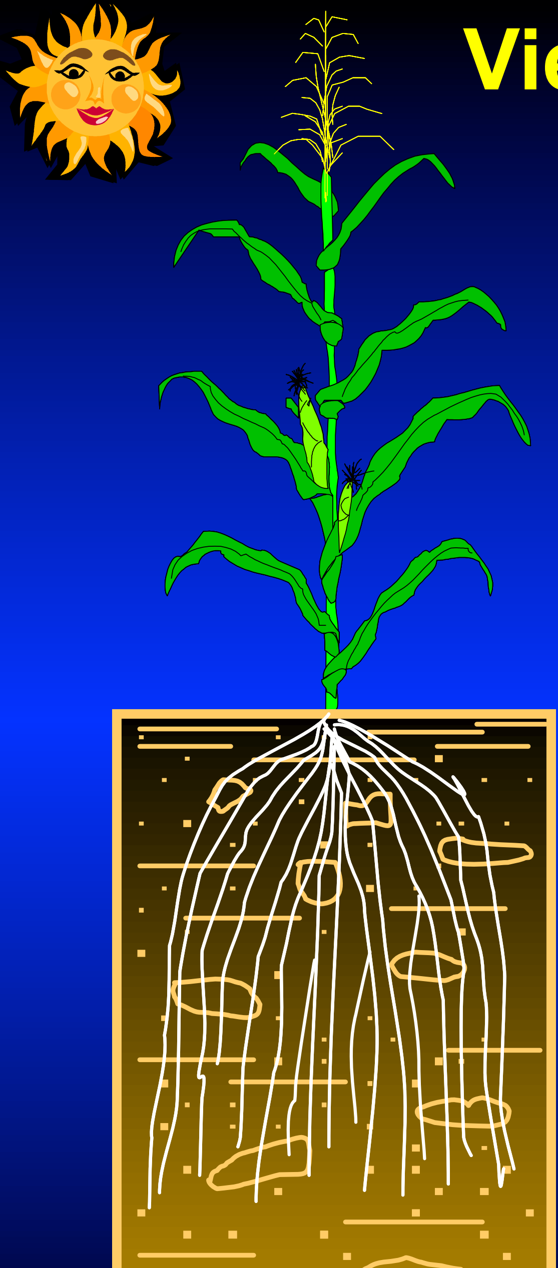
Beckism #101

Plants are the main source of our food/energy generation.

View the plant as carbon!

(~ 45% C)

Plant Power



Carbon capture

Carbon storage

Energy storage

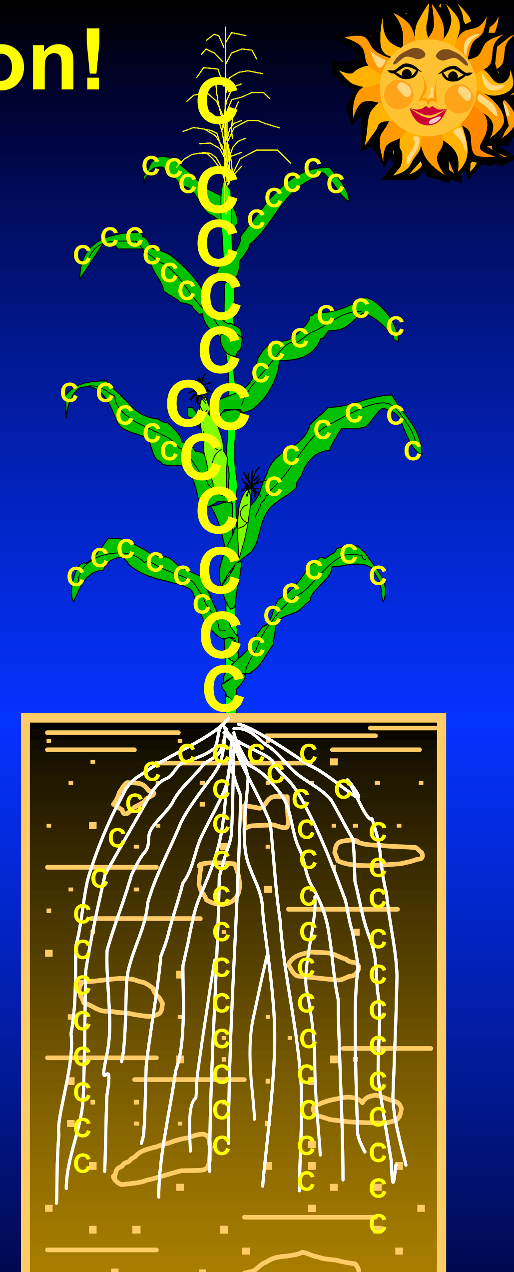
Food source

Energy source

Soil carbon input

Environmental benefits

Quality of Life



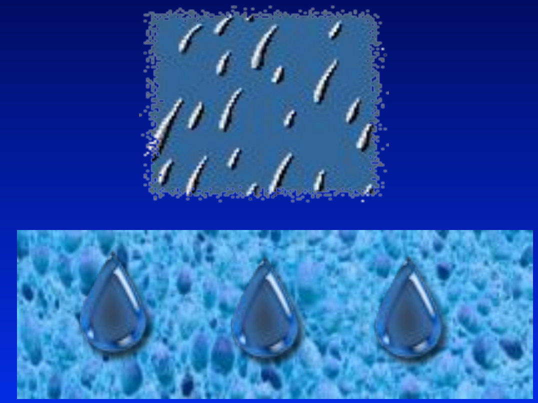
Conservation depends on plant management!

Carbon is the "C" that starts "C"onservation!

Conservation is our first step toward food security!

Soil organic matter acts like a "sponge" for water retention and release to plants.

sponge



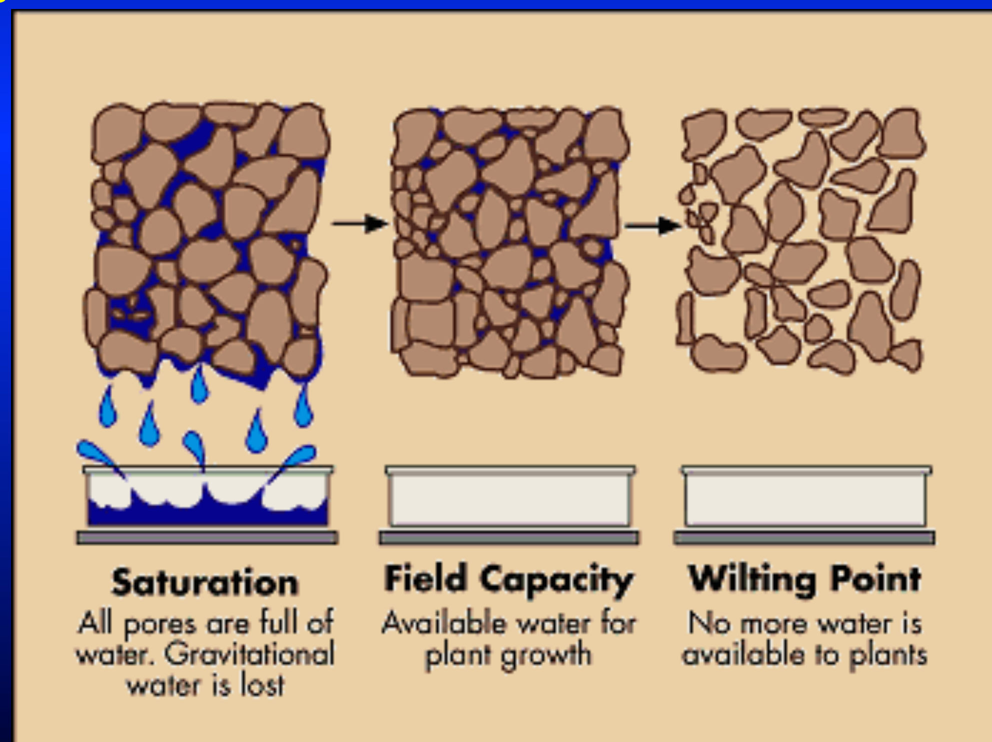
SOM "sponge"

Soil high in carbon is rich in "spongy organic matter" that releases nutrients to crops and holds more than its own weight in water.

Available water capacity (AWC) is analogous to a bucket. The larger the “bucket”, the more water stored available to the plants.

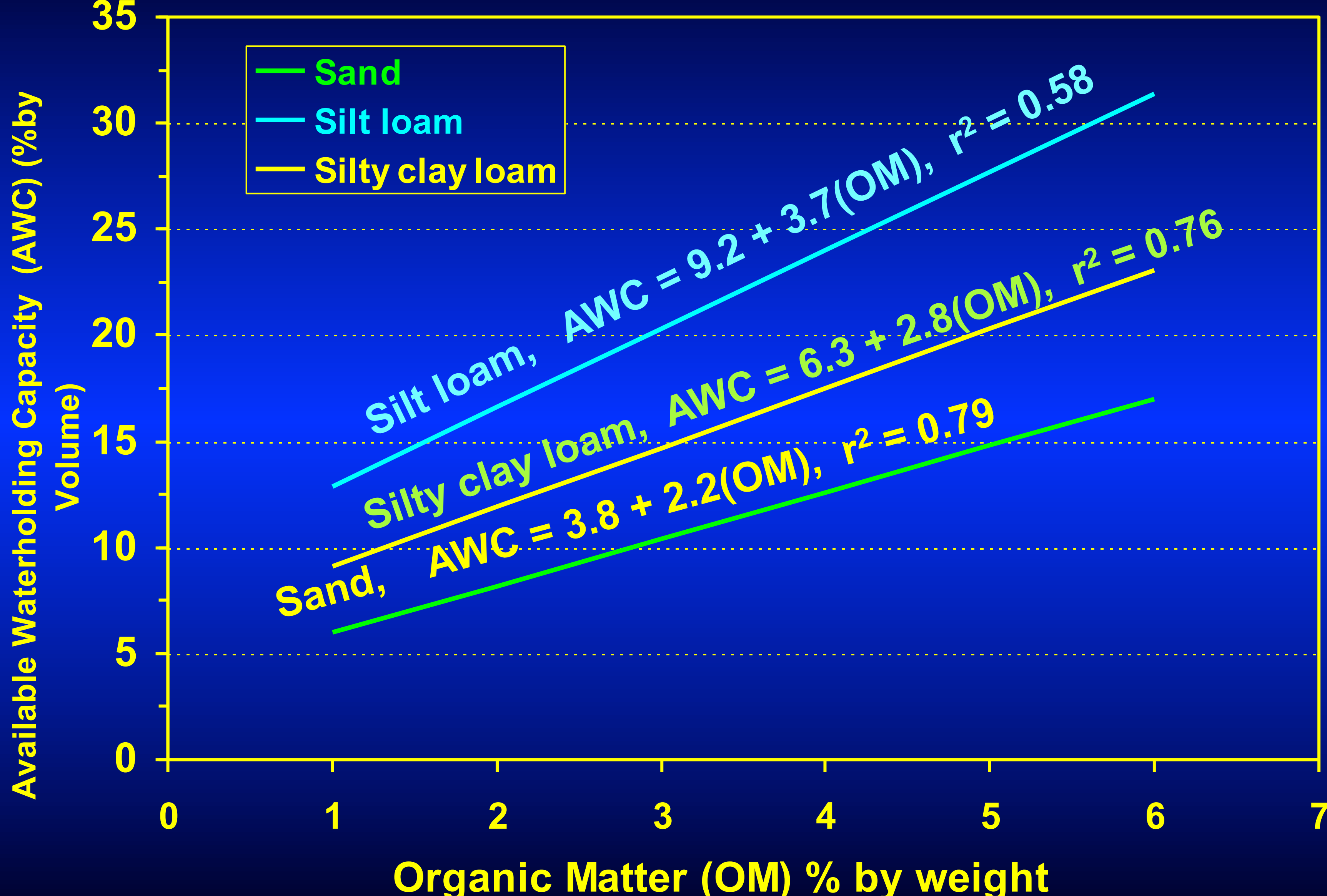
AWC = textural water + SOM “sponge” water

Sand, silt, clay



Source: Dept. of Agriculture Bulletin 462, 1960

SOM increases available water holding capacity!



Source: Berman Hudson, 1994. JSWC 49:189-194

Sand soil

Available Water holding Capacity (AWC)

(cm H2O/ 25 cm soil)

(in. H2O/ ft. soil)

1.0 cm
0.48 in.

1.5 cm
0.72 in.

2.0 cm
0.96 in.

2.6 cm
1.25 in.

SOM = 0% **1%** **2%** **3%**

soil matrix water **+** Soil organic matter “sponge” water

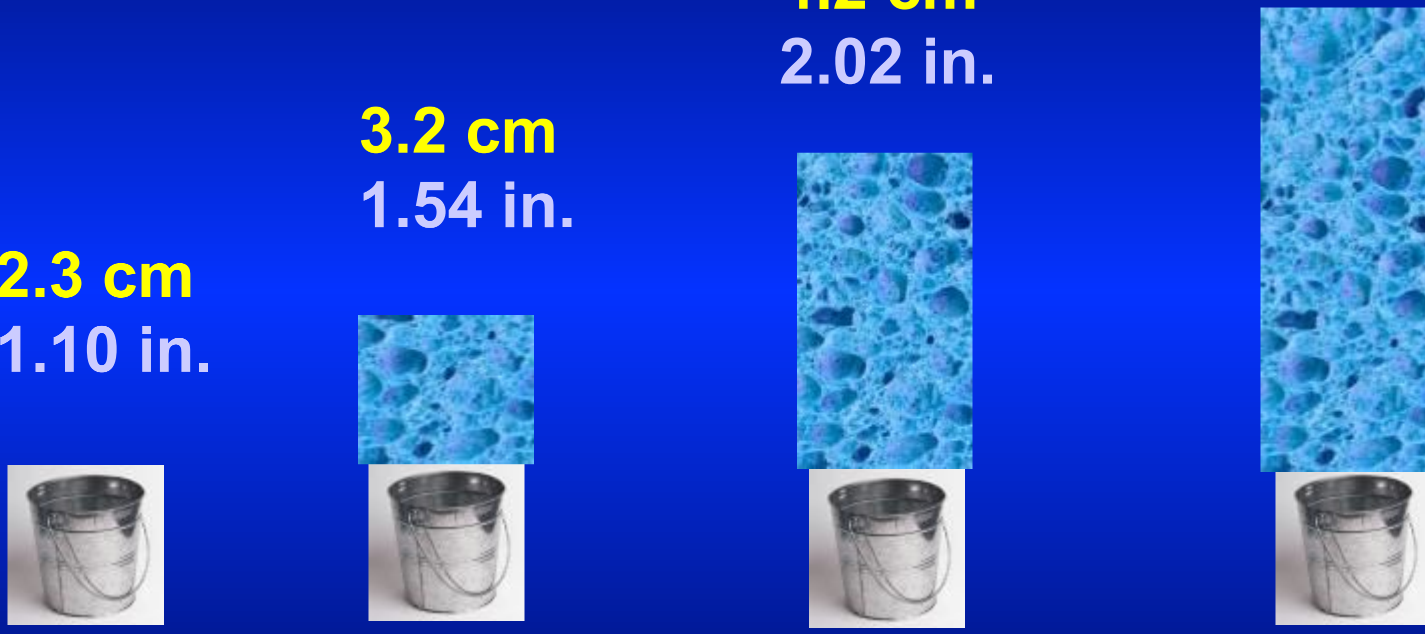
Source: Berman Hudson, 1994. JSWC 49:189-194.

Silt loam soil

Available Water holding Capacity (AWC)

(cm H2O/ 25 cm soil)

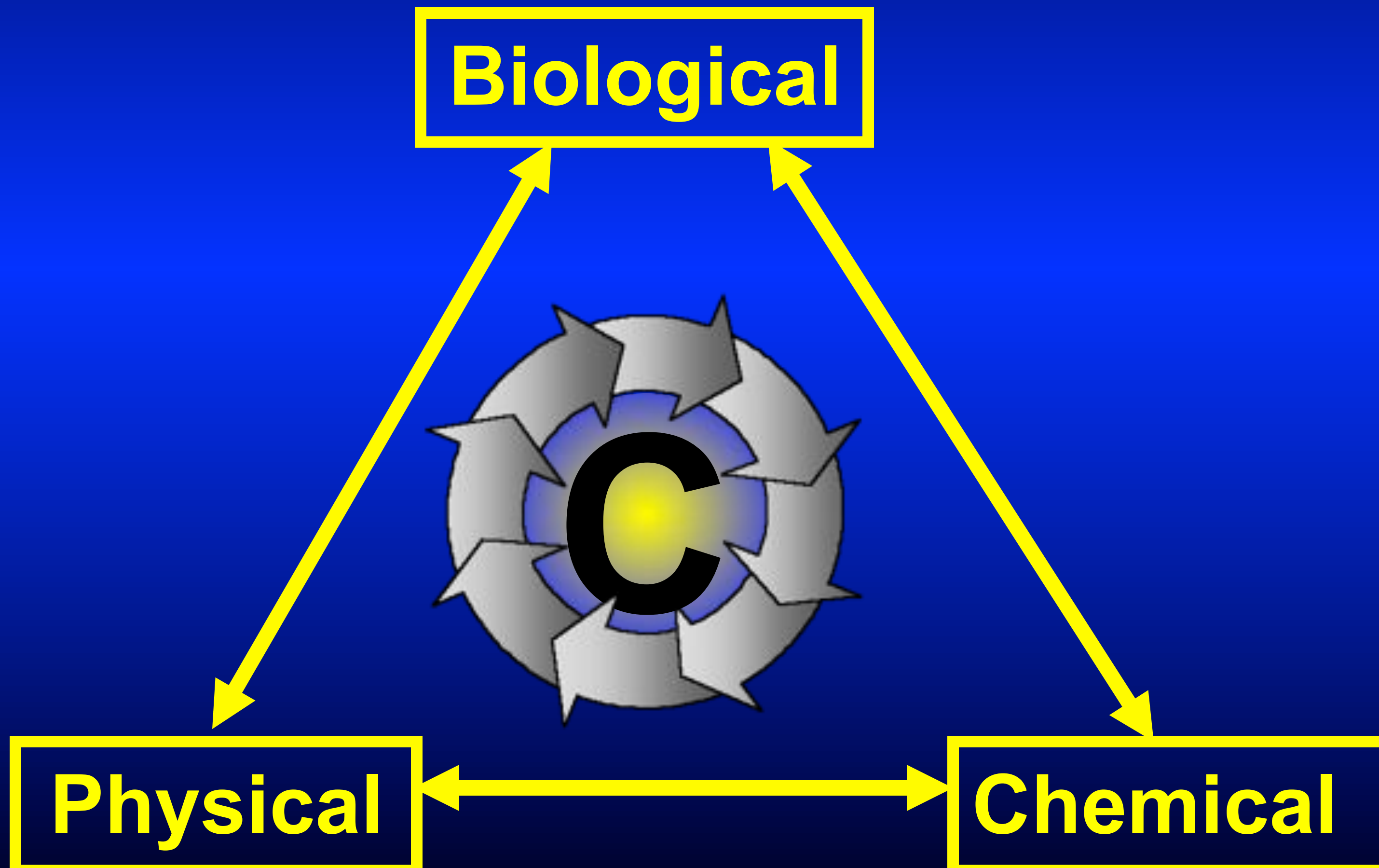
(in. H2O/ ft. soil)



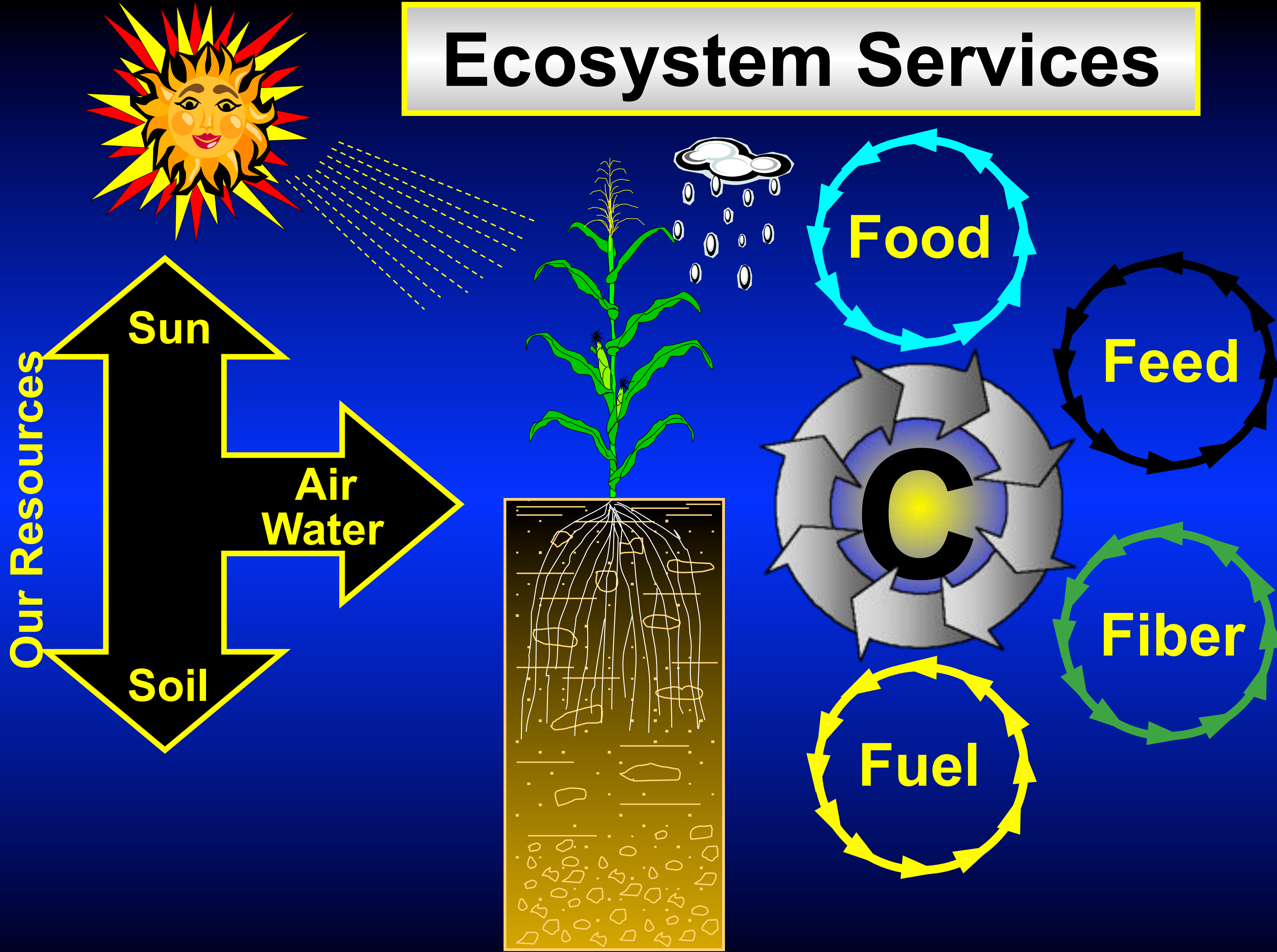
soil matrix water + Soil organic matter "sponge" water

Source: Berman Hudson, 1994. JSWC 49:189-194.

Carbon is the center of the "Soil Magic Triangle".



Ecosystem Services



Soil degradation:

1. Inversion tillage

2. Crop residue removal

Soil restoration:

1. No tillage systems

2. Crop residue retention + cover crops

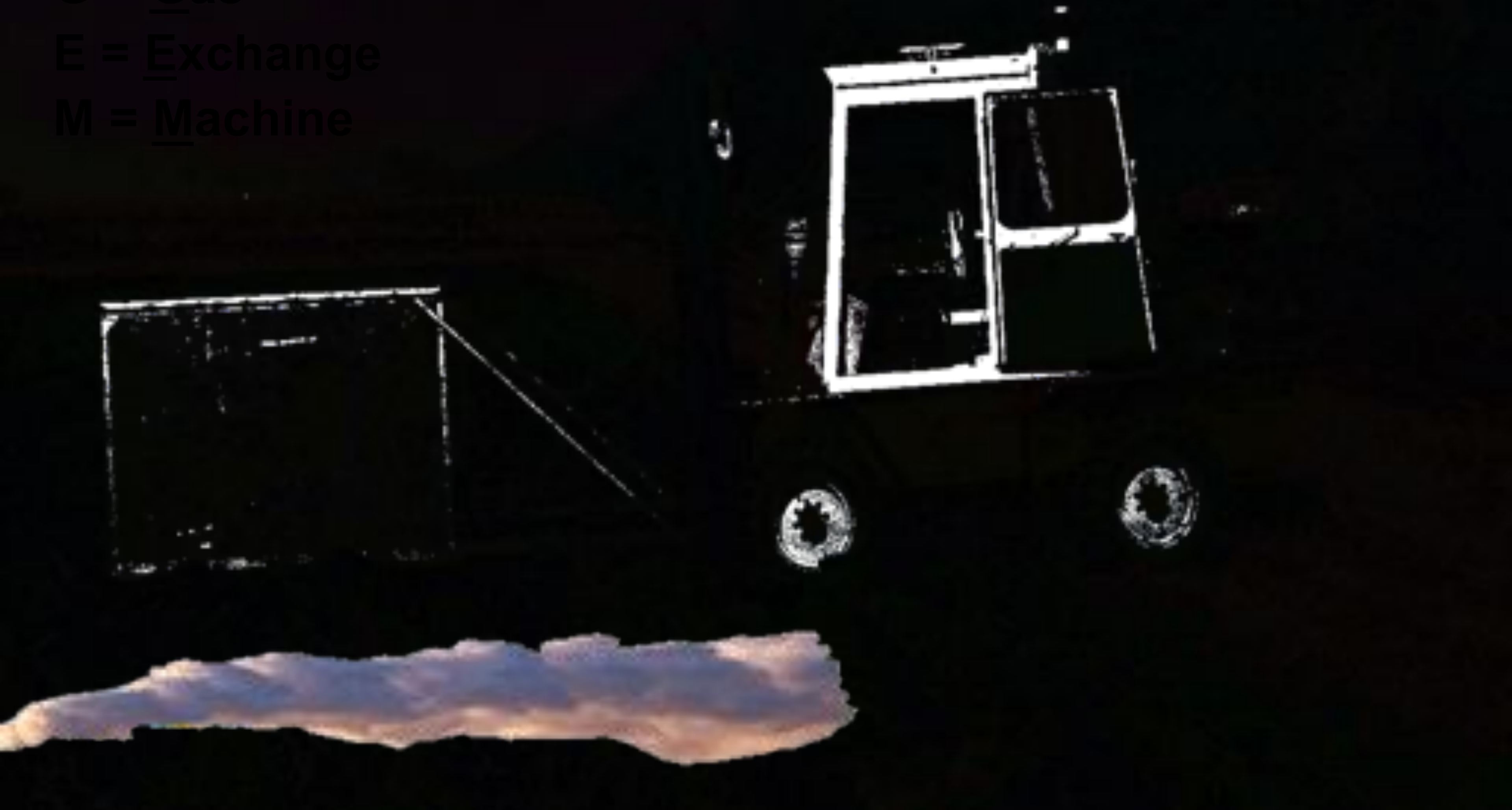
Source: Jerry Hatfield

No. 1 Environmental Enemy in Production Agriculture

Tillage-induced Carbon Dioxide Loss

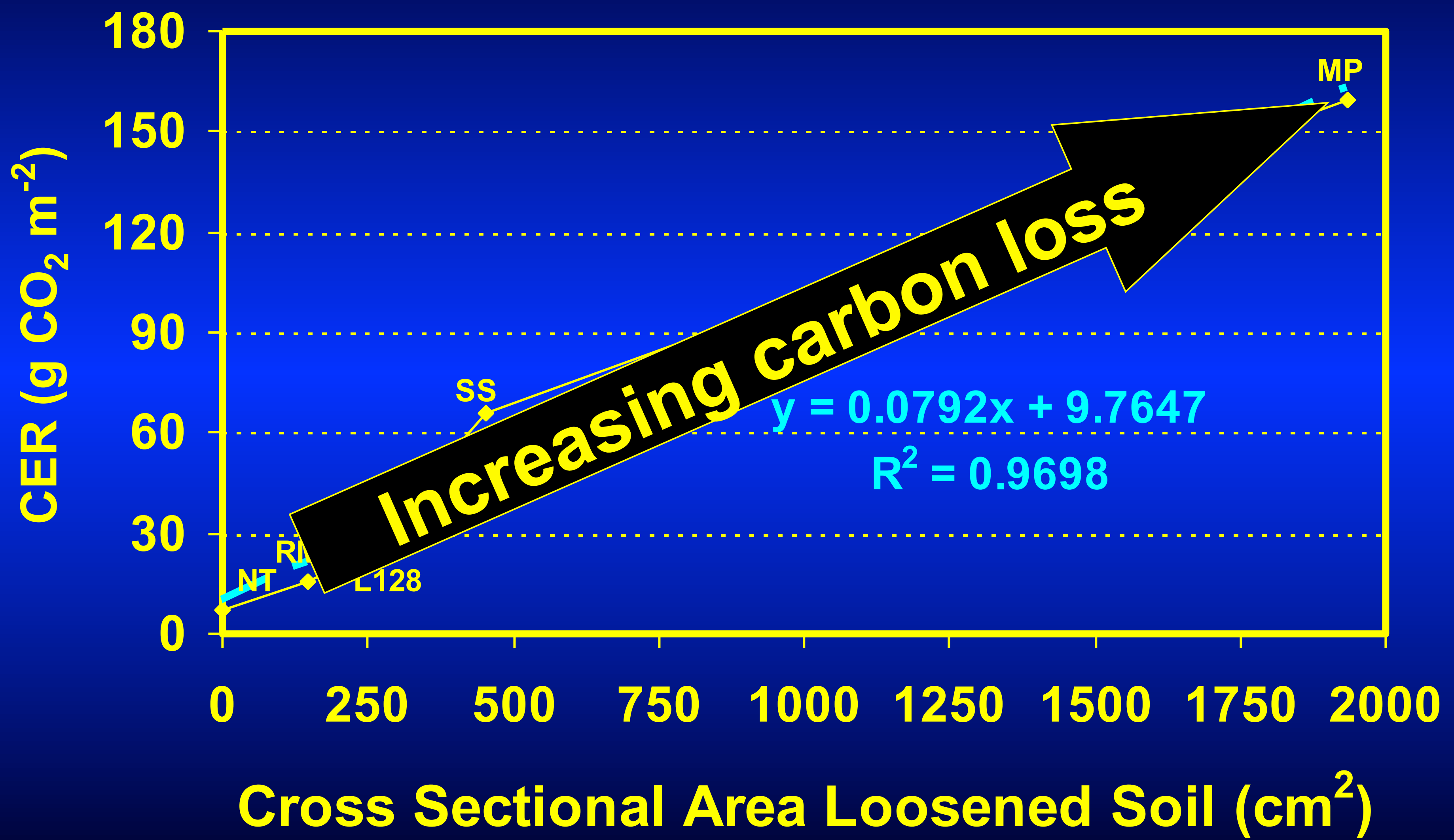
MR. GEM

M = Mobile
R. = Research
G = Gas
E = Exchange
M = Machine



Invisible effects of invisible forces!

Strip Tillage #1 3 June 1997 Swan Lake
Cumulative Carbon Dioxide Loss after 24 hours



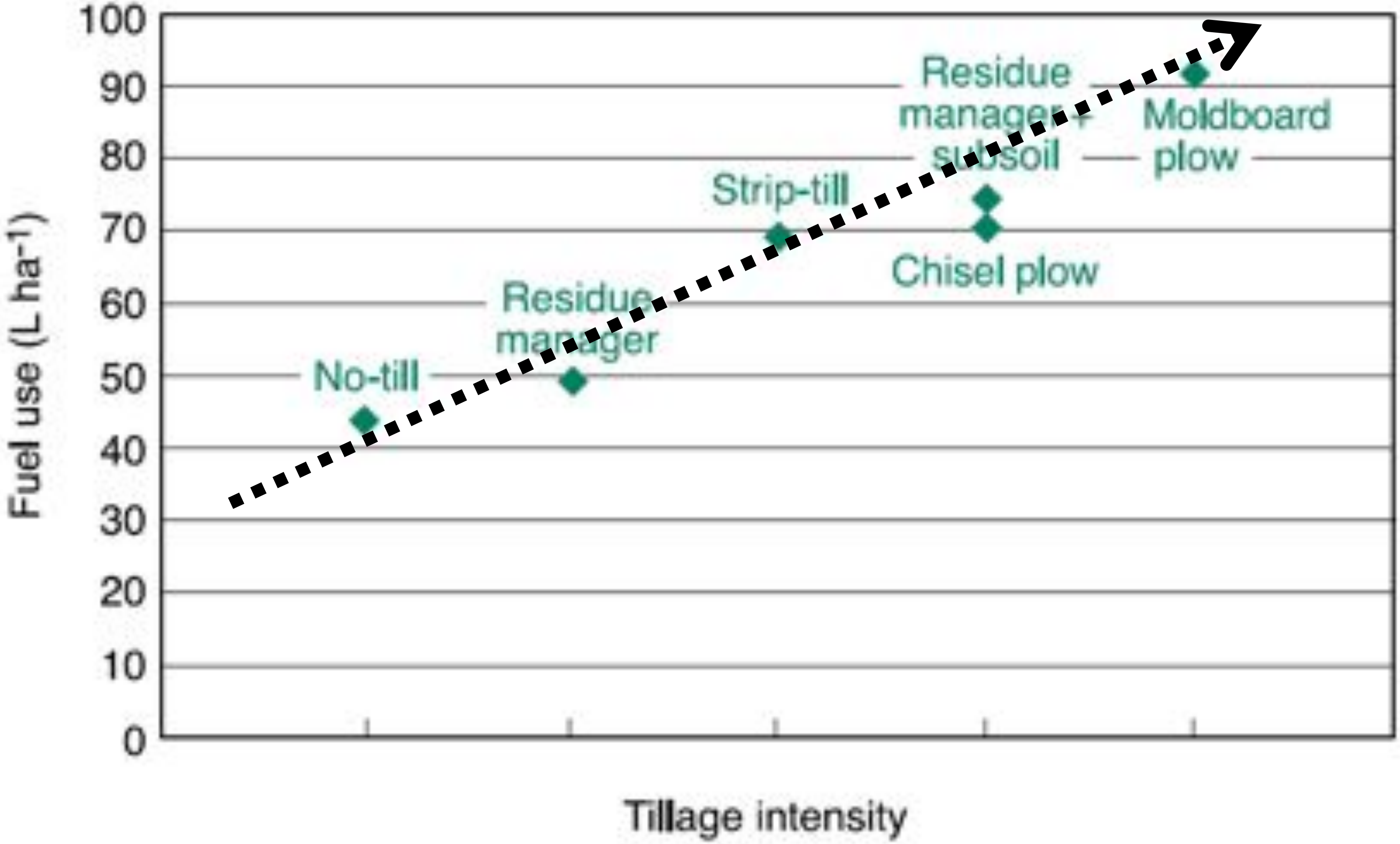
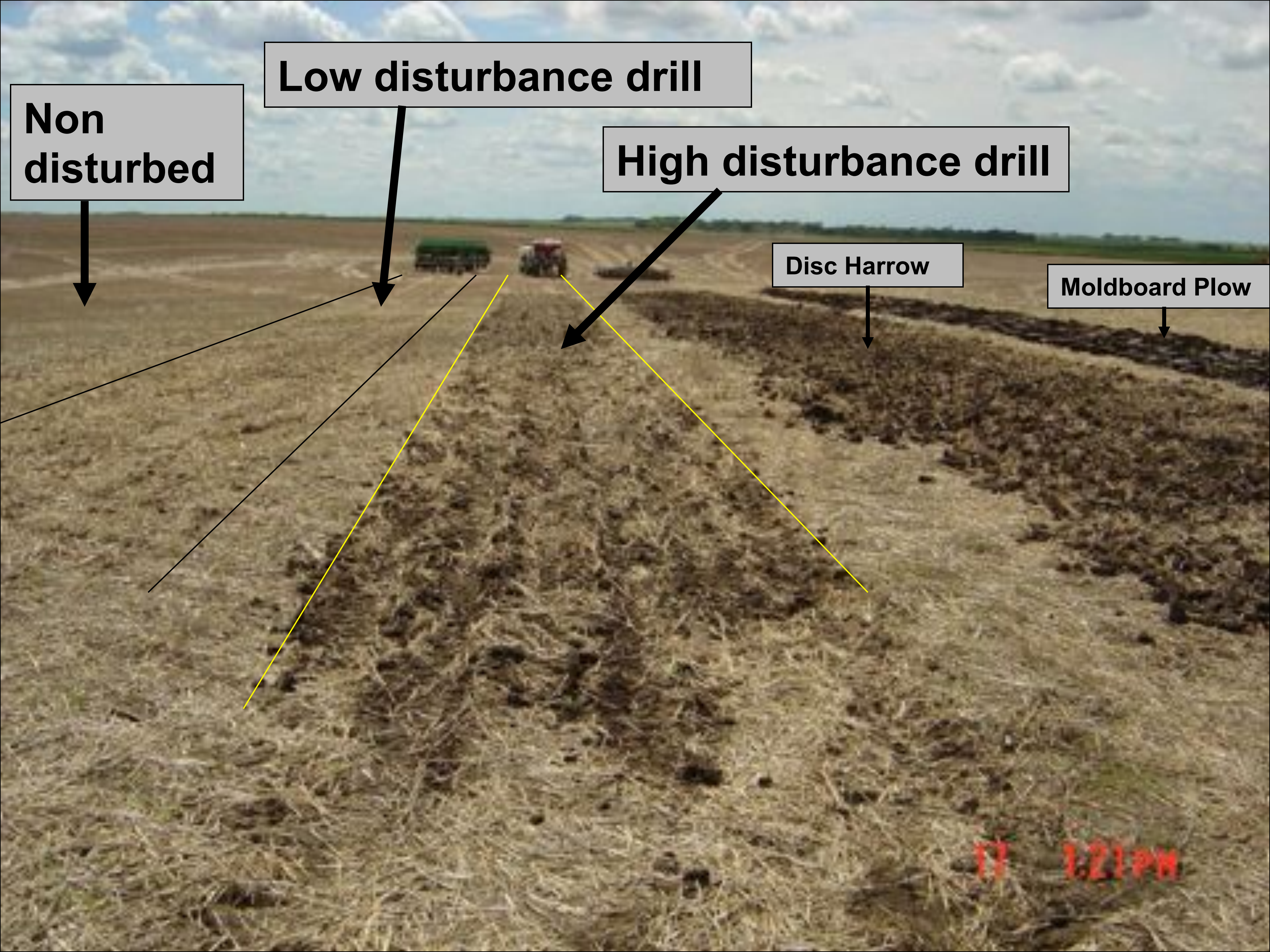


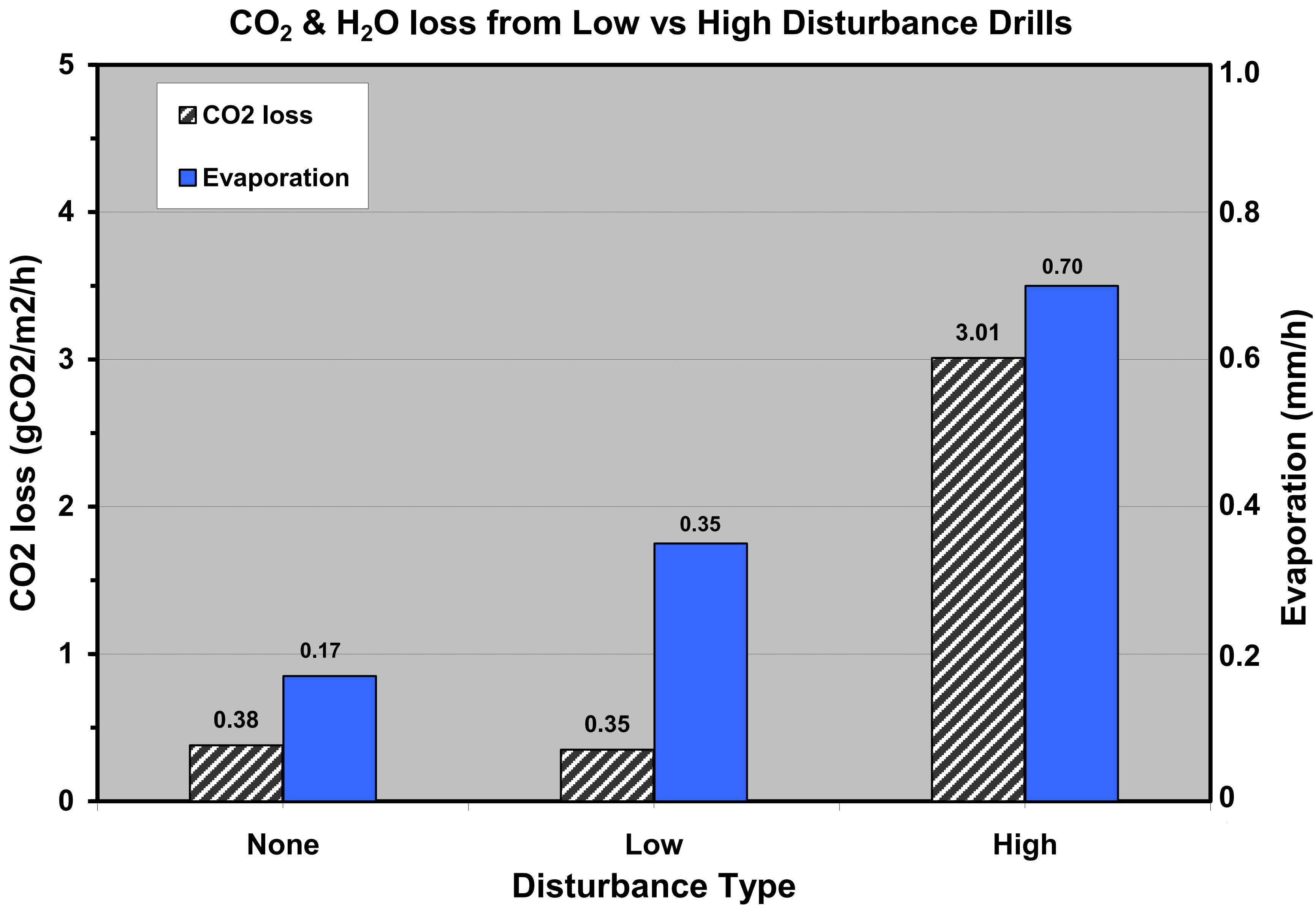
Figure 1. Fuel use as related to tillage intensity (data from Archer and Reicosky 2009).

Previous work showed tillage-induced CO_2 emissions were proportional to soil volume disturbed.

What do large “no till” seeders due to CO_2 emissions?


Comparison of No Till Drills
Low disturbance drill
High disturbance drill


Non disturbed
Low disturbance drill
High disturbance drill
Disc Harrow
Moldboard Plow



CO2 & H2O loss from Low vs High Disturbance Drills
CO2 loss
Evaporation
CO2 loss (gCO2/m2/h)
Evaporation (mm/h)
0
1
2
3
4
5
0
0.2
0.4
0.6
0.8
1.0
0.38
0.17
0.35
0.35
3.01
0.70
None
Low
High
Disturbance Type

There's a jungle full of life living in your belly button!

There's a jungle full of life living in your soil!

The bellybutton project is out to "educate the public about the role of bacteria play in our world. Bacteria are always present on our skin and in our bodies."

What's in your belly button?

Your belly button is crawling with billions of bacteria, in all shapes, sizes and appetites.

It's warm, dark and moist, a perfect home for bacteria.

The tiny bacteria in the "jungle of microbial diversity" are generally harmless.

Everybody's bellybutton carries a different cast of characters.

Minneapolis Star Tribune, 12/7/2012.
Jiri Huler, Lead scientist, NCSU

What's in your soil?

Your soil is crawling with billions of critters (bacteria, fungi, arthropods, nematodes, worms, and animals) in all shapes, sizes and appetites.

The temperature is variable, it's dark and moist, a perfect home for soil biology.

The tiny critters in the "jungle of microbial diversity" are generally harmless.

Everybody's soil carries a different cast of characters.

** 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.
Earthworms are allergic to cold steel! Mike Bell
Tillage creates twin problems:
-- Accelerated soil degradation
-- Accelerated soil erosion

“Turmoil of Tillage”

The soil is a natural living 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

tsunami

forest fire

tornado

hurricane

all rolled into one perturbation event!

“Carbon” coverings for the soil!

Dead crop residue =
“passive protective blanket”

Both are food sources for the soil biology!

Live crop biomass =
“active protective blanket”

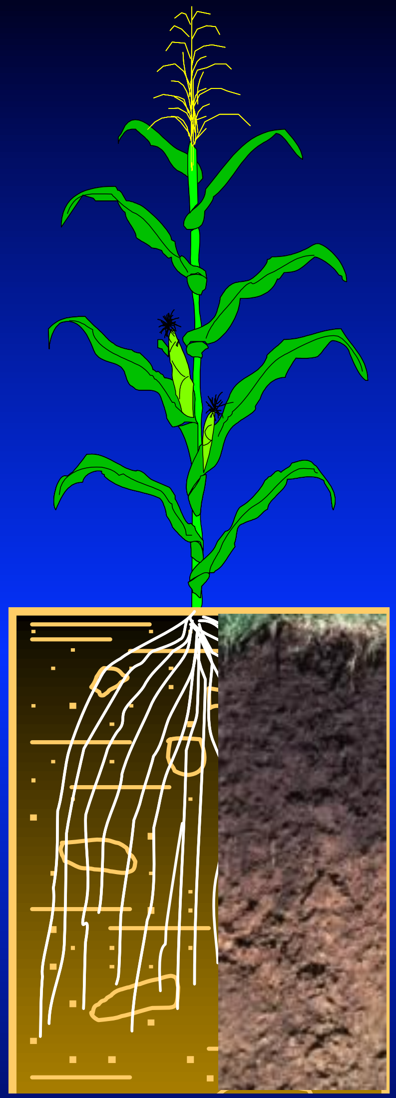
Which is better for the soil biology?

"Pulling" iron?

vs

"Pushing" carbon!

Natural Fertility



Crop biomass ~ 46 %C

CO_2 ← Microbial and fungal decomposition Biological activity = Nutrient release → CO_2

Soil organic matter = 58 %C

Difference = 12 %C

C, H, O, N

P K Ca Mg Mn Cu

S Cl Zn Bo Mo Fe Na

Terminology Transition away from Tillage

We need to change our vocabulary!

~~No Till~~ → **Conservation Management**

Emphasize conservation

De-emphasize tillage

Emphasize crop residue management

De-emphasize soil disturbance

Carbon Management

Conservation without compromise!

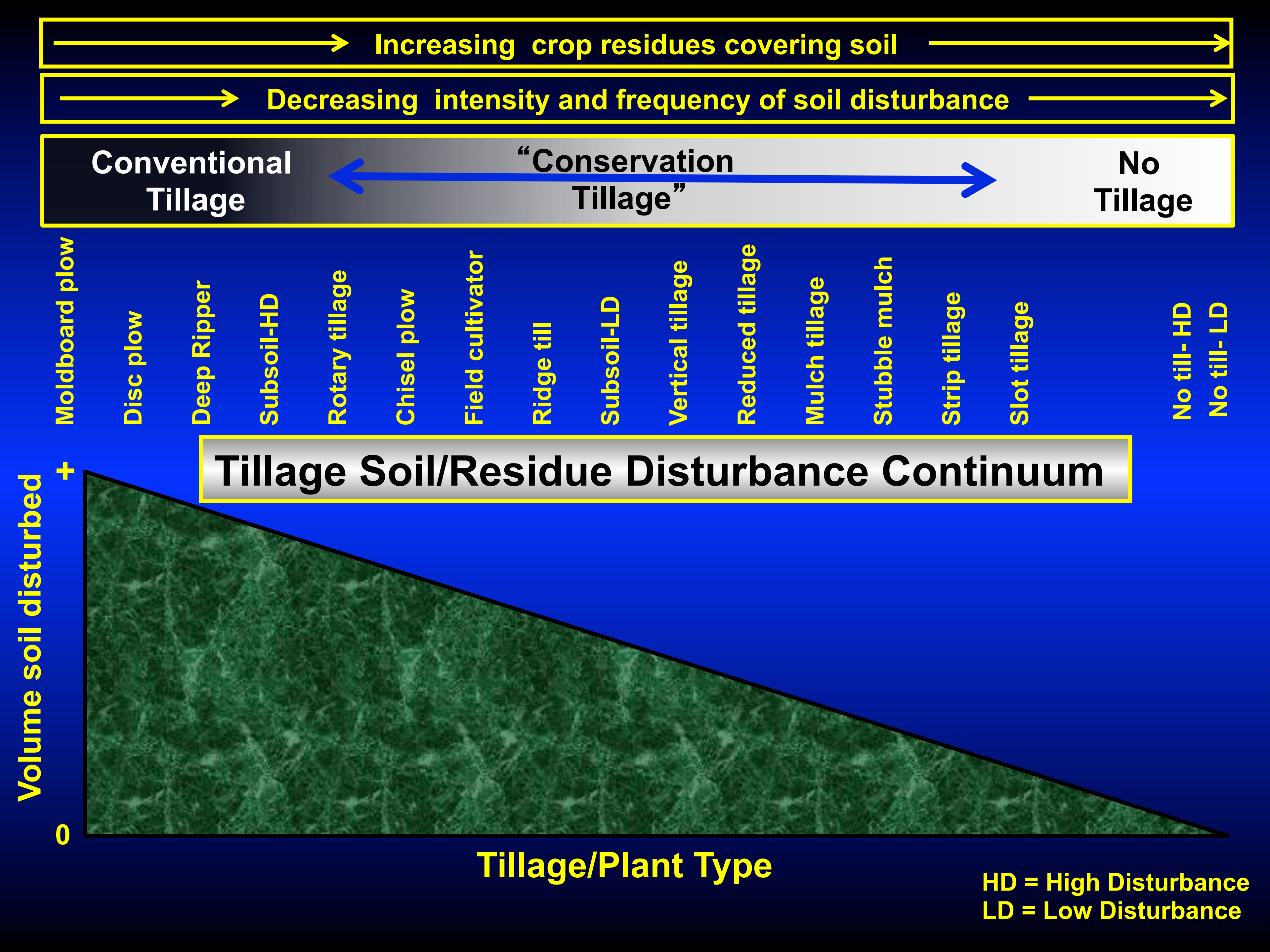
Conservation tillage is a broad term used to define "any" tillage system with primary objective of "reducing soil and water loss."

Conservation tillage, however, has "loose limits" on the definition of soil disturbance and residue management.

“Conservation Tillage” dilemma

“Conservation Tillage” terminology leads to confusion due to the diversity of machinery that leads to the wide range of soil disturbance and crop residue burial.

We need more attention to quantitative details in understanding the most critical factors for soil degradation related to soil tillage and crop residue removal/burial.


Increasing crop residues covering soil
Decreasing intensity and frequency of soil disturbance
Conventional Tillage
“Conservation Tillage”
No Tillage
Moldboard plow
Disc plow
Deep Ripper
Subsoil-HD
Rotary tillage
Chisel plow
Field cultivator
Ridge till
Subsoil-LD
Vertical tillage
Reduced tillage
Mulch tillage
Stubble mulch
Strip tillage
Slot tillage
No till- HD
No till- LD
Tillage Soil/Residue Disturbance Continuum
+
Volume soil disturbed
0
Tillage/Plant Type
HD = High Disturbance
LD = Low Disturbance

Conservation:

**“Touch the earth lightly, use the earth gently,
Nourish the life of all the world in our care.”**

Source: Shirley Erina Murray, 1992

The action of conserving something, in particular. Preservation, protection, or restoration of the natural environment, natural ecosystems, vegetation, and wildlife.

Conservation is a word to be respected, revered and used to describe agriculture. However, conservation does not belong in the same sentence with tillage.

What is Conservation Tillage?

The phrase "conservation tillage" is an oxymoron. An oxymoron is a figure of speech in which incongruous or contradictory terms appear side by side.

Any form of intensive tillage is not a form of conservation for the way intensive tillage degrades and fractures the natural soil structure. Tillage destroys or disturbs the ecosystems of soil fauna so important for nutrient cycling. Tillage moves the soil down slope via tillage erosion. Intensive tillage loosens the soil and buries the crop residue, allowing the soil to dry, setting up the system for severe erosion with the next high-intensity rainfall event.

Tillage Soil Disturbance Continuum

Most disturbance | **Least disturbance**

Conventional Tillage ⟷ "Conservation Tillage" ⟷ No Tillage

Conventional Tillage

Zero Conservation
Much tillage

"Conservation Tillage"

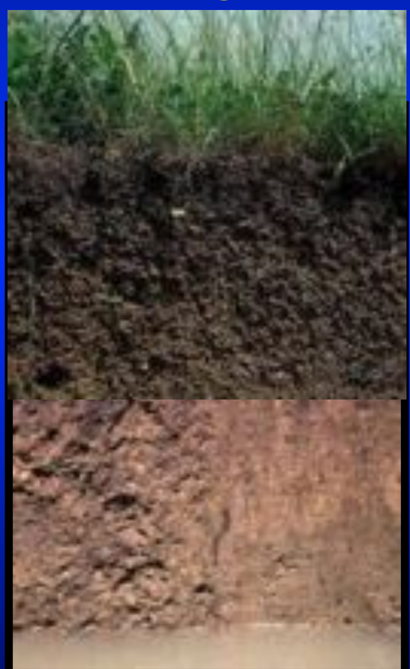
Some Conservation
Some tillage

Direct Seeding

Much Conservation
Zero tillage

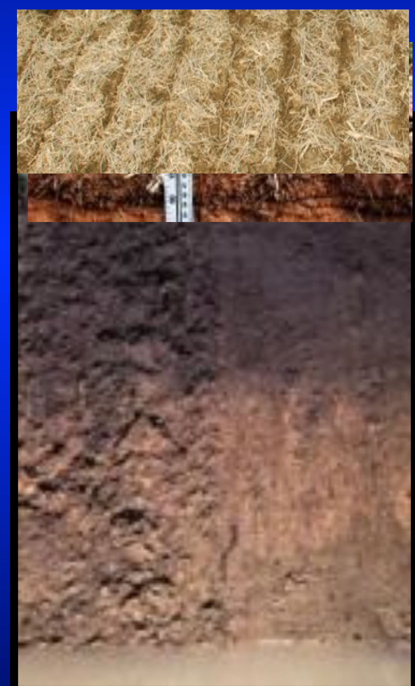
Conventional tillage = inversion tillage
Conservation tillage = non-inversion tillage
Direct seeding is close to natures way!

Nature's way



Biological tillage

No till



Minimum disturbance to 5 cm

Conservation tillage

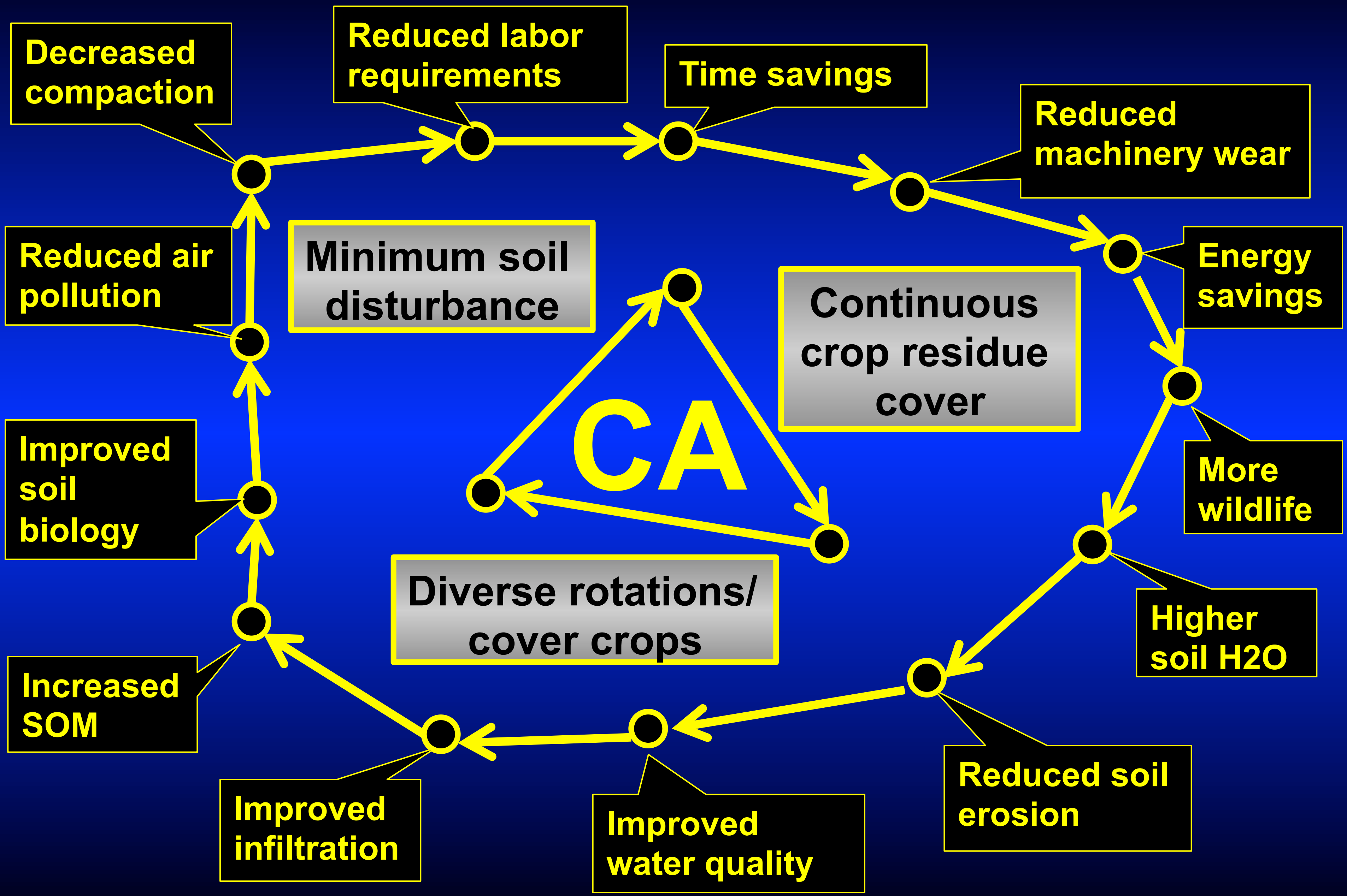
Non-inversion tillage to 46 cm

Conventional tillage

Inversion tillage to 30 cm

After Hartwig Callsen

"Connect the dots around Conservation Agriculture"



Soil Carbon Sequestration

Environmental benefits are spokes that emanate from the Carbon hub.

- increased water holding capacity and use efficiency
- increased cation exchange capacity
- reduced soil erosion
- improved water quality
- improved infiltration, less runoff
- decreased soil compaction
- improved soil tilth and structure
- reduced air pollution

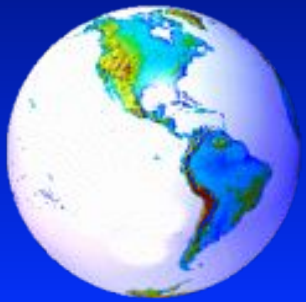
Carbon

- reduced fertilizer inputs
- increased soil buffer capacity
- increased biological activity
- increased nutrient cycling and storage
- increased diversity of microflora
- increased adsorption of pesticides
- gives soil aesthetic appeal
- increased capacity to handle manure and other wastes
- more wildlife

Agriculture's Wheel of Fortune!

Conservation as in Conservation Agriculture is our only option.

C



Save a little time

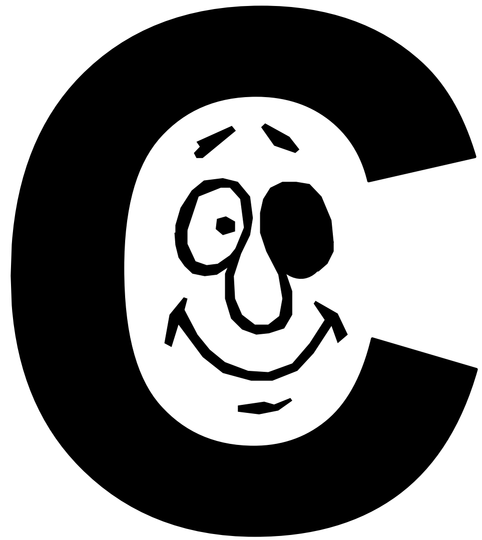
Save a little money

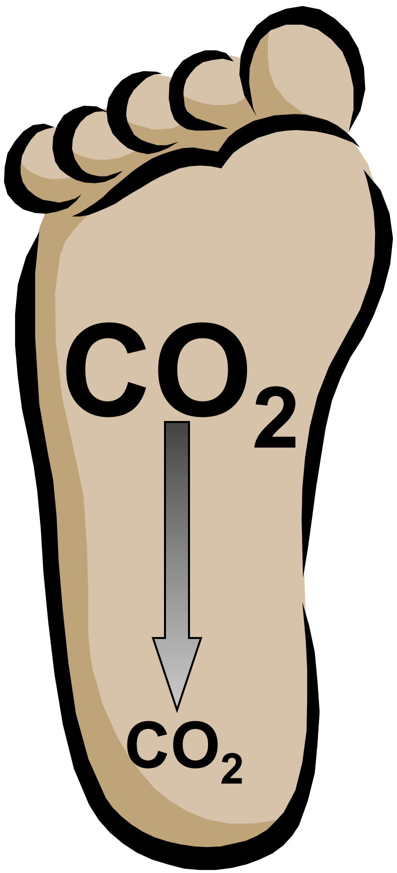
Save little carbon

Save a little planet

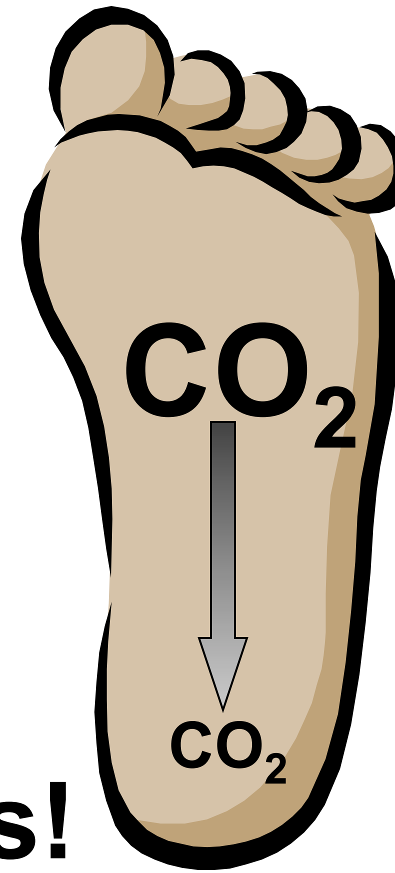
Credit: Ken Scott, Clear Lake, IA

Carby Carbon





Keep your carbon footprint small and manage carbon for ecosystem services!



Best done with Conservation Agriculture!