

8th World Congress Conservation Agriculture

Virtual Webinar Nov. 5, 2020

Conservation Agriculture Systems: The Living Soil and Ecosystem Services

by

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Nature is connected to everyone and everything!



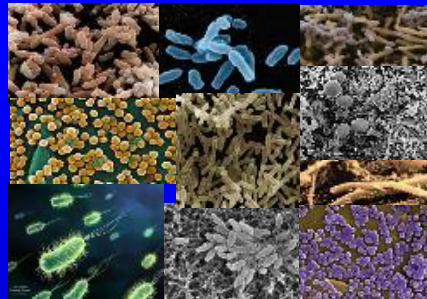
Nature is communicating with us! Are we paying attention?

Nature is our friend!

Nature provides our resources!

(sun, soil, water, air (CO₂, O₂, N₂), human intellect, biodiversity)

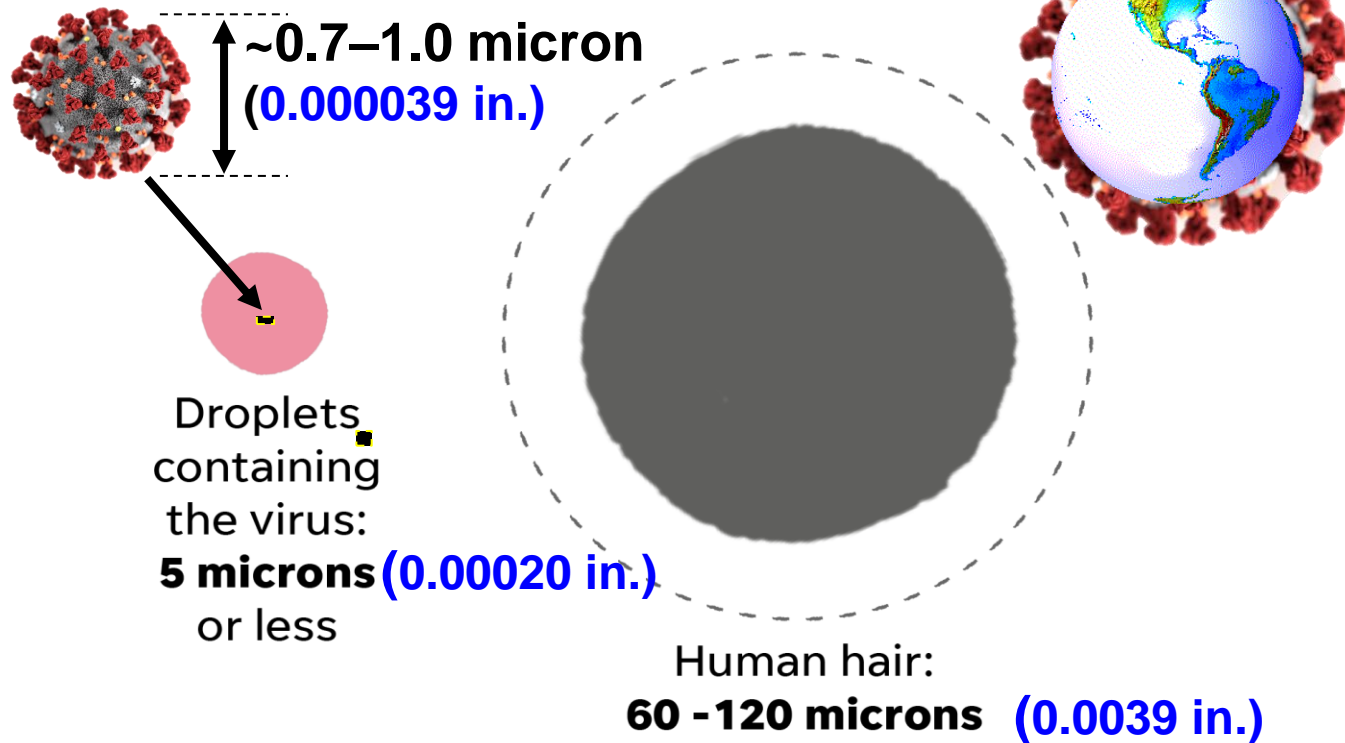
Nature provides “bio-power” in living soils!



The “living soil” starts our food chain!
We must understand “living soil” if we want to live in harmony with Nature.

Nature's "biological power" is illustrated by the tiny microscopic piece of biology called Covid-19, powerful enough to bring the world to its knees.

Coronavirus-19



An average human hair is ~100 times larger than a virus cell!

The COVID-19 pandemic has further highlighted the importance of the relationship between humans and nature, and the profound consequences to our well-being and survival that can result from continued biodiversity loss and degradation of agricultural ecosystems. Around the globe, Covid-19 currently has the upper hand.

Simplified Definitions

Ecology the branch of biology that deals with the relations of organisms to one another and to their physical surroundings.

An ecosystem is a community of living organisms interacting with each other and their nonliving environment.

Ecosystem services are the many and varied benefits to humans provided by the natural resources and the environment in the form of healthy ecosystems. Ecosystem services can be considered nature's contributions to Humanity.

Ecosystem Services (ES)

Ecosystems are characterized by interacting geological, hydrological, climatological, ecological and anthropogenic processes. Strong interactions between these processes and components require a systems approach to understand the response to dynamic changes.

“Soil organic matter generates and regulates every ecosystem services that sustains life on earth” Source - Rattan Lal- 2020 World Food Prize Laureate

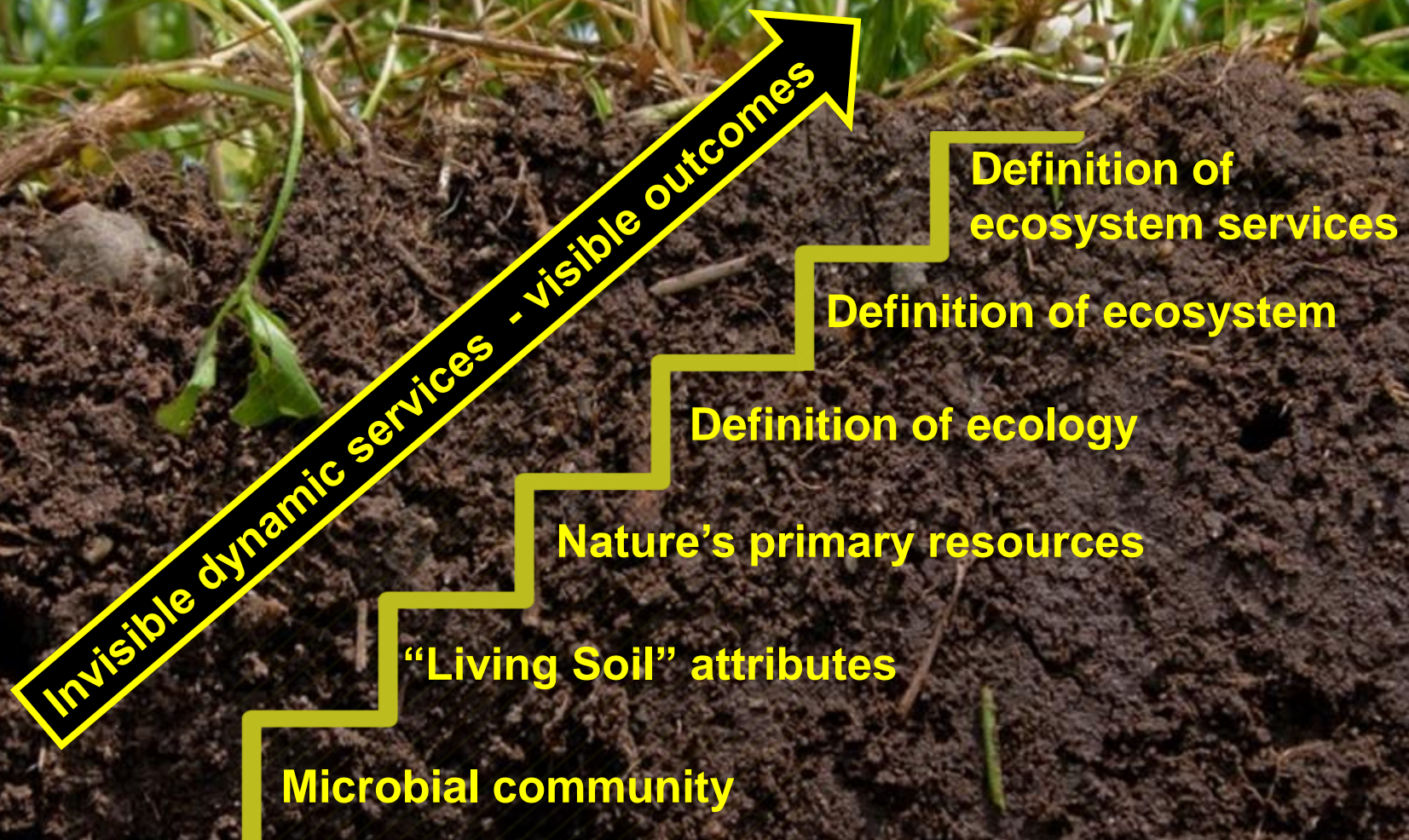
International Union for Conservation of Nature:

addresses gaps and capacity needs on the sustainable management, conservation and restoration of ecosystems.

Soil biodiversity and soil organic carbon are vital to the way ecosystems function and they largely determine the role of land in producing food, storing water, and mitigating climate change. They are the key to unlocking the multiple economic and environmental benefits -- the multi-functionality -- of land.

Source: Laban, Peter, Graciela Metternicht and Jonathan Davies. 2018. Soil Biodiversity and Soil Organic Carbon: keeping drylands alive. Gland, Switzerland: IUCN. viii + 24p. www.iucn.org/resources/publications

Understanding Ecosystem Services (ES)



Soil Carbon

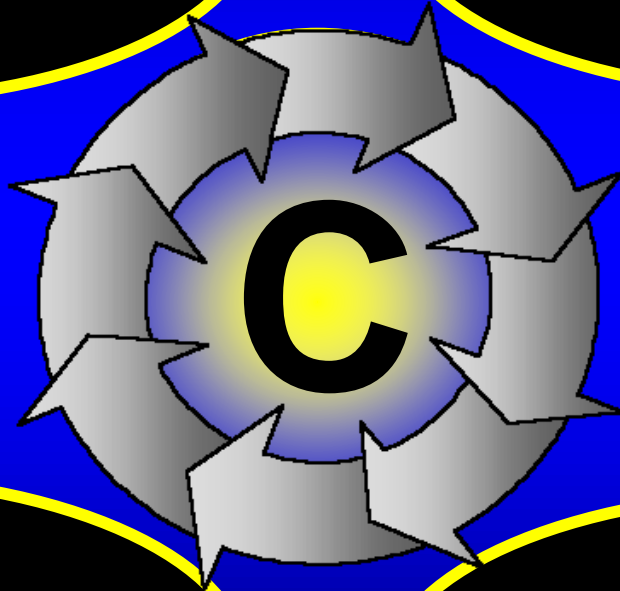
“Living soils” ecosystem services!

Provisioning

Supporting

Regulating

Cultural



“Living soils” ecosystem services!

Provisioning

genetic resources of plants and animals, medicines, food, fiber, wood and drinkable water;

Supporting

photosynthesis, biomass production, production of atmospheric oxygen, soil formation and retention, nutrient cycling,

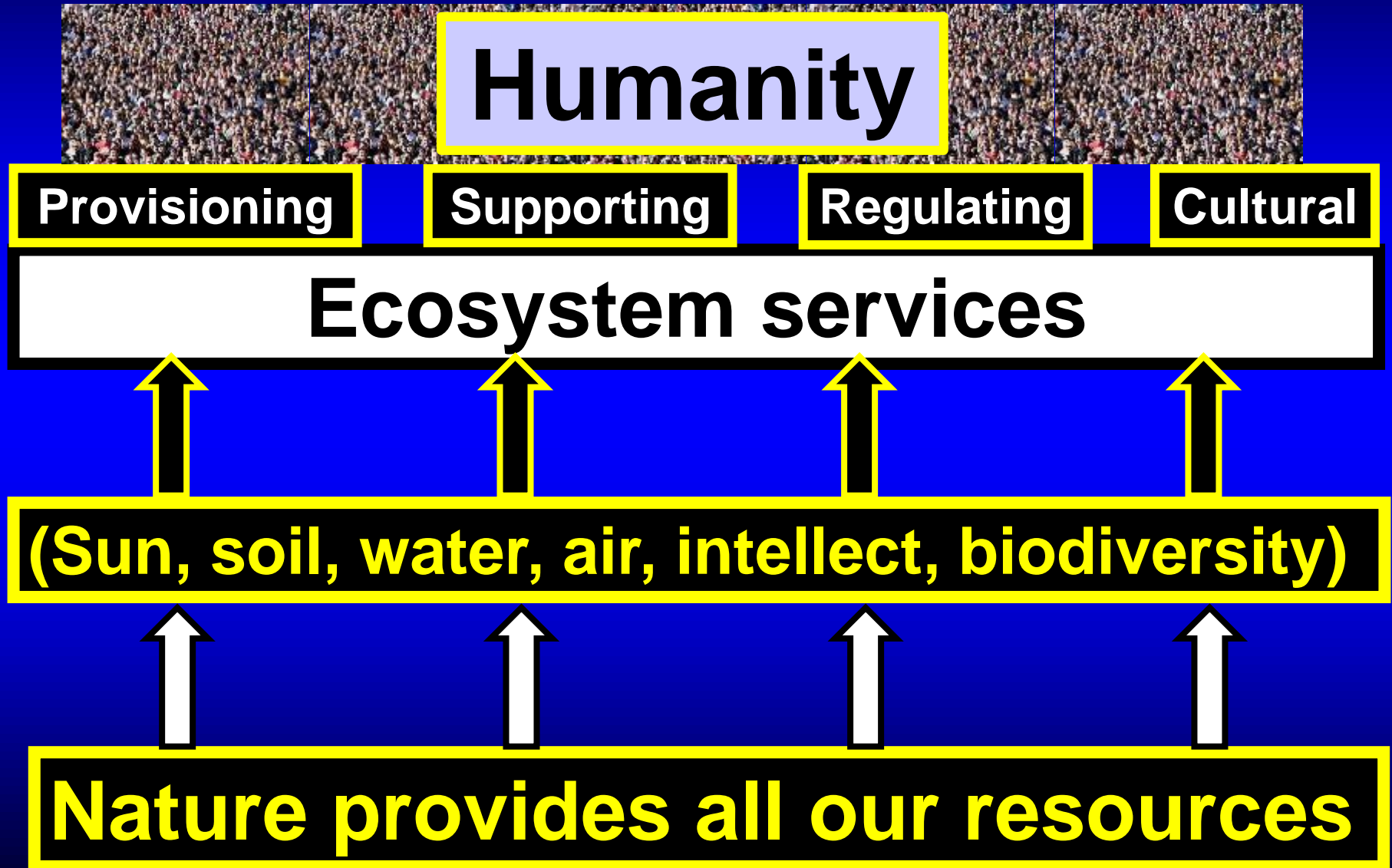
Regulating

climate, water, flood and disease control, natural hazard regulation, water purification, waste management, pollination, pest control.

Cultural

non-material benefits, spiritual enrichment, cognitive development, reflection, recreation, social relations, aesthetic experience, knowledge, aesthetic values,

Ecosystems support all life



Can world's farms be key to biodiversity?

Story Source: Catrin Einhorn New York Times

Extensive ecosystem restoration is central to conserving biodiversity and stabilizing the climate. Returning a strategic 15% of the world's farmland to Nature could:

- **Spare 60% plant and animal extinctions**
- **Sequester ~30% of carbon build-up in atmosphere**

Nature-based solutions to climate, food and water security, and sustainable livelihoods, requires biodiversity remain the foundation for a sustainable future.

Conservation Agriculture is Nature's way!

Data Source: Strassburg, B.B.N., Iribarrem, A., Beyer, H.L. et al. 2020. Global priority areas for ecosystem restoration. Nature (2020). <https://doi.org/10.1038/s41586-020-2784-9>

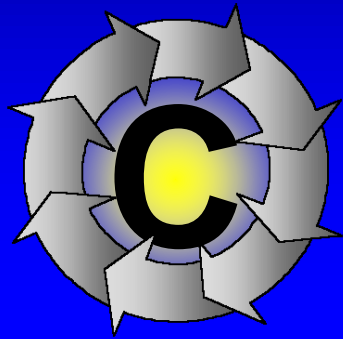
Working With Mother Nature Improving Soil Health.

“As to methods, there may be a million and then some, but principles are few. The man who grasps principles can successfully select his own method.” Ralph Waldo Emerson

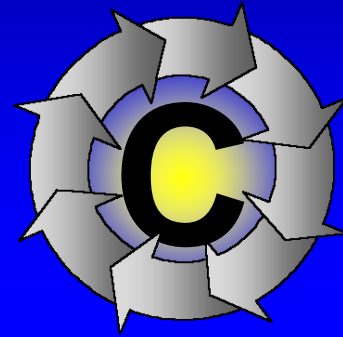
CA is Nature's way!

- **Continuous minimum soil disturbance**
- **Continuous maximum vegetative cover**
- **Continuous maintenance of biodiversity**

“Carbon Centered Agriculture”



CONSERVATION AGRICULTURE SYSTEMS:



**- healthy food, affordable, profitable,
environmentally friendly, and a regenerative
solution to our food security.**

**Understanding Nature’s “Bio-Power” is
the key to Conservation Agriculture!**

“Carbon Centered Agriculture”

C

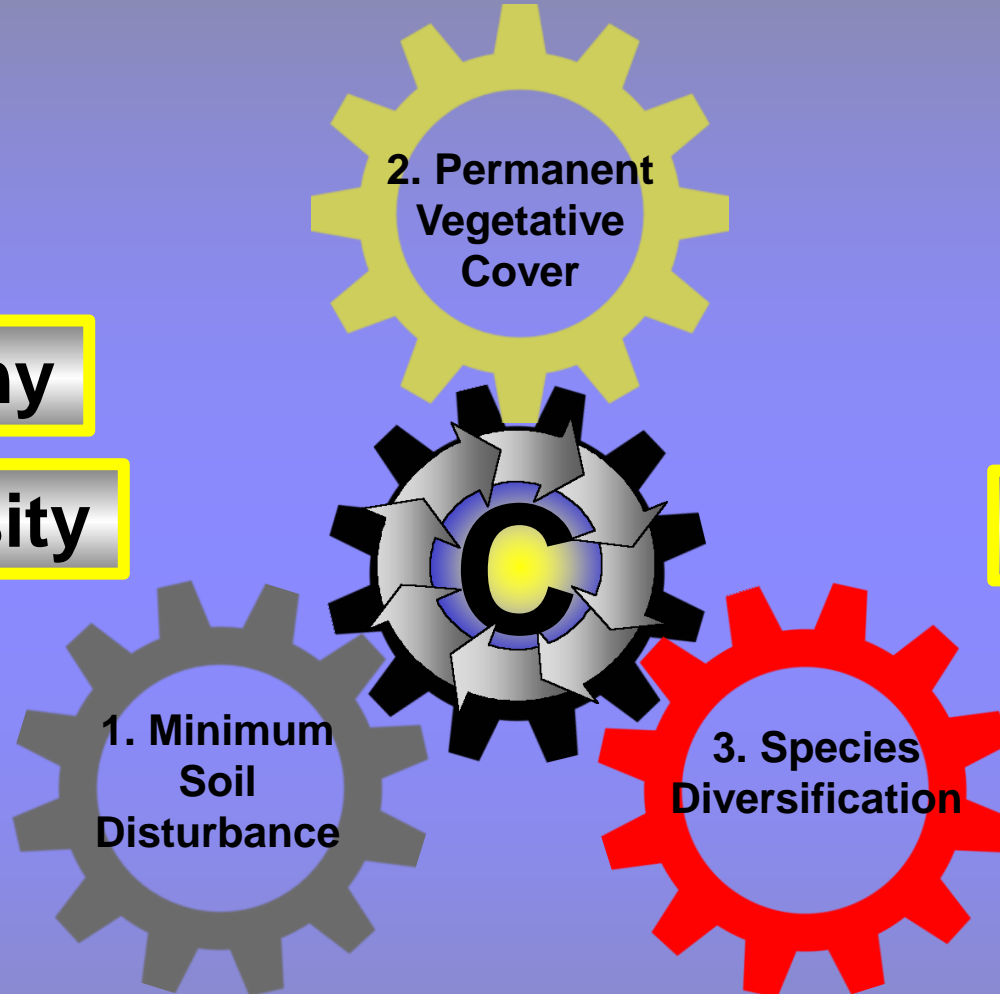
Synchrony

Biodiversity

A

Synergy

Harmony



Site specific adaption of technology & complementary agricultural practices

Conservation Agriculture

Many ecosystem services based on carbon management!

**Habitat
provisioning**

**Primary
productivity**

**Carbon cycling
& storage**

**Water cycling
& storage**

**Nutrient cycling
& storage**

Ecosystem services

Conservation Agriculture Systems

Site specific adaption of technology & complementary agricultural practices

**1. Minimum soil
disturbance
(No-till, direct
seeding)**

**2. Permanent
vegetative cover
(Plant biomass, stubble,
residue)**

**3. Species
diversification
(Diverse rotations & cover
crop mixes)**

Soil Carbon = “Living Roots” + “Living Soil”

“Ecosystems and the services they provide are financially significant and to degrade and damage them is tantamount to economic suicide.”

Klaus Toepfer, head of the U.N. Environment Program.



“Tillage Double Negative”

Tillage-induced CO₂ loss and diesel fuel consumption are proportional to the volume of soil disturbed in tillage.



Plow tillage is the “master of disaster”; it sets the soil up for erosion and degradation, causes carbon loss, causes water loss, increases pollution and decreases soil, water, and air quality.

Denmark



Intensive soil tillage opens the “all-you-can-eat buffet” for the birds and microbes.

Minnesota, USA



Tillage creates twin problems:
-- Accelerated soil degradation
-- Accelerated soil erosion

Tillage is an abiotic operation with a biotic disturbance!

“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



asteroid impact



forest fire



tsunami



hurricane



tornado



all rolled into one perturbation event!

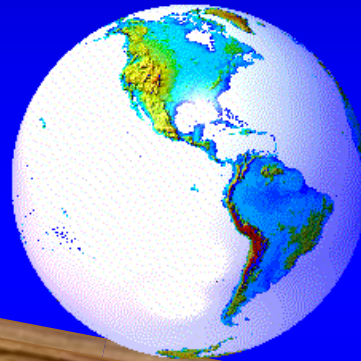
**We have “unbalanced” nature with tillage.
Conservation Agriculture is part of the solution!**

**1. Too *little* C
in the soil**



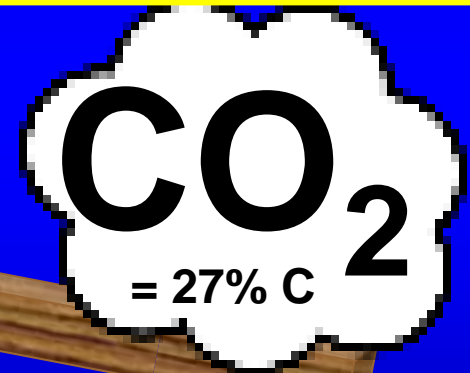
C

**“C”limate
“C”risis!**



**2. Too *much* C
in the air**

**1. Decarbonize
the air.**

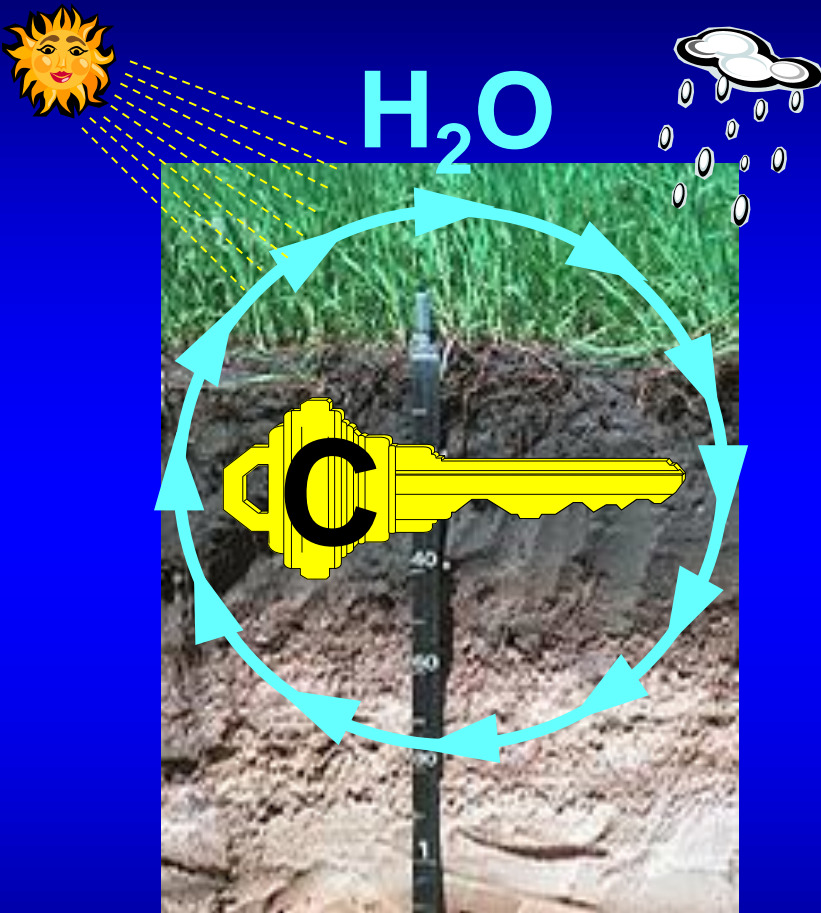


C

**2. Recarbonize
the soil.**

**Food &
energy
security**

Plant carbon is our greatest water management tool!



C Increases:

infiltration, evapotranspiration, soil tilth, soil structure, available water holding capacity, water use efficiency, water storage, root depth, soil biological activity, water quality, root and worm bio-pores, aeration, nutrient cycling, drainage

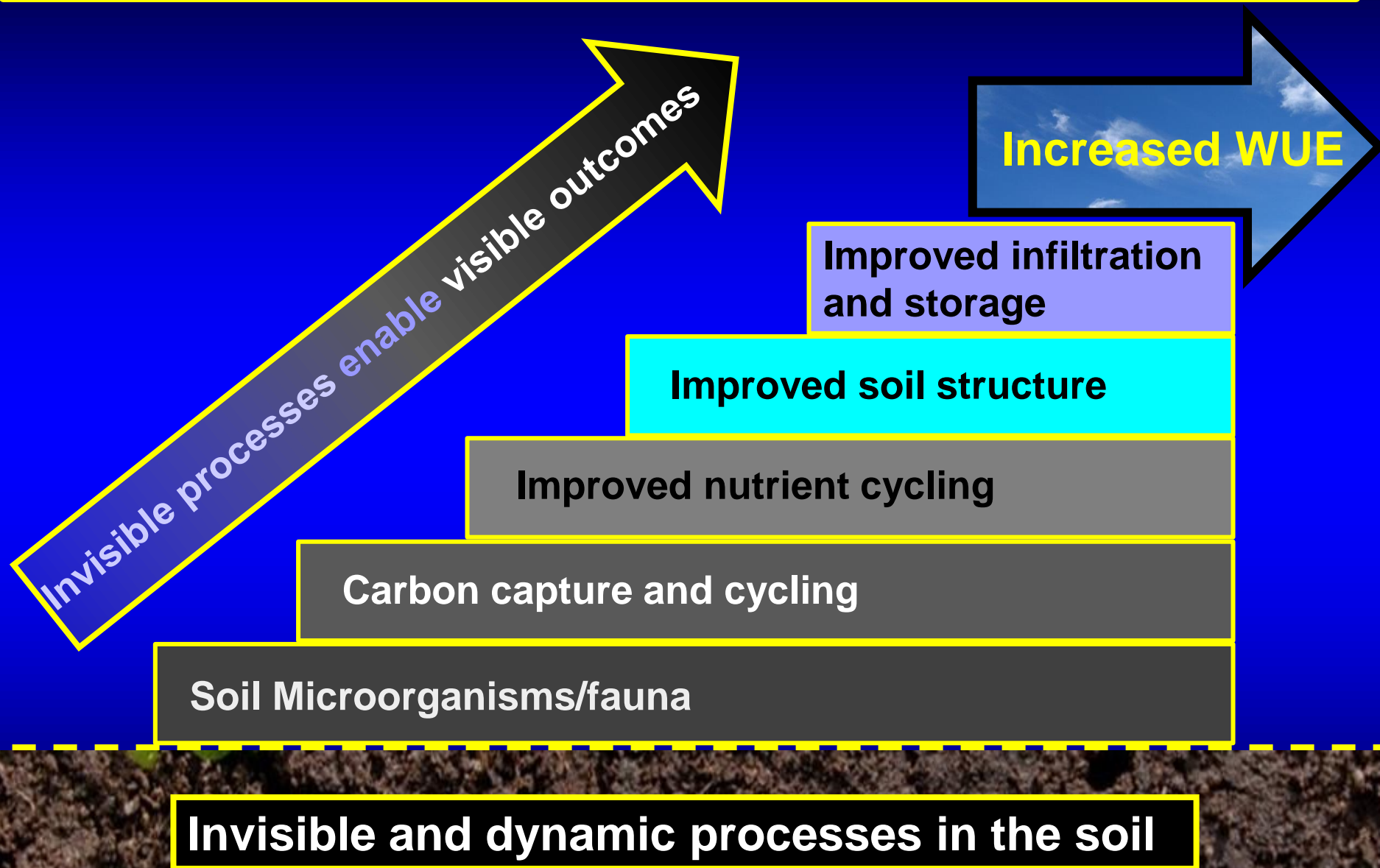
C Decreases:

Soil runoff, erosion, evaporation, sediments, temperature, crusting, pollution, compaction, desertification,

“C” = live and dead plant leaves, stems, roots, biomass, residue, mulch layer, POM, SOM, manure, humus and humic acids.

Good carbon management is required for maximum water use efficiency.

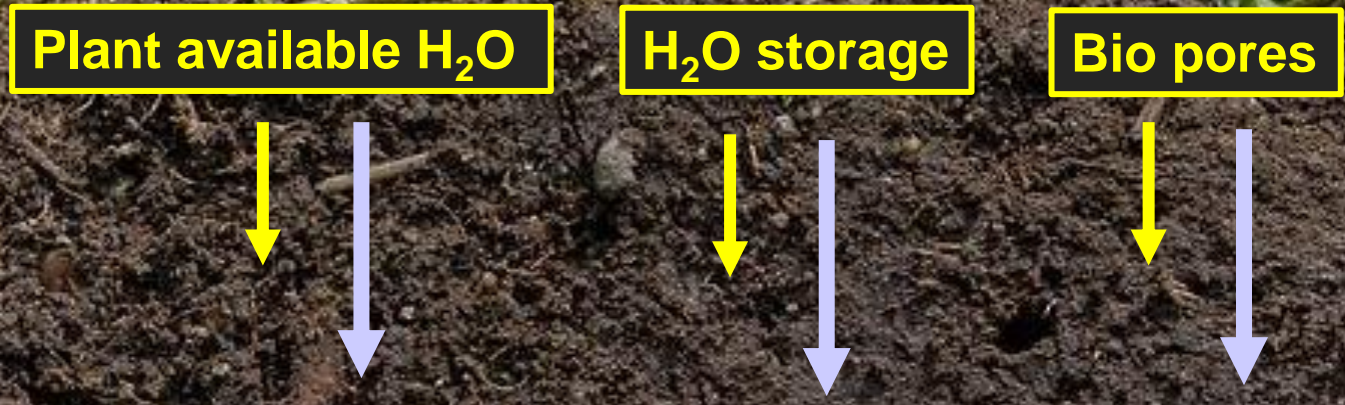
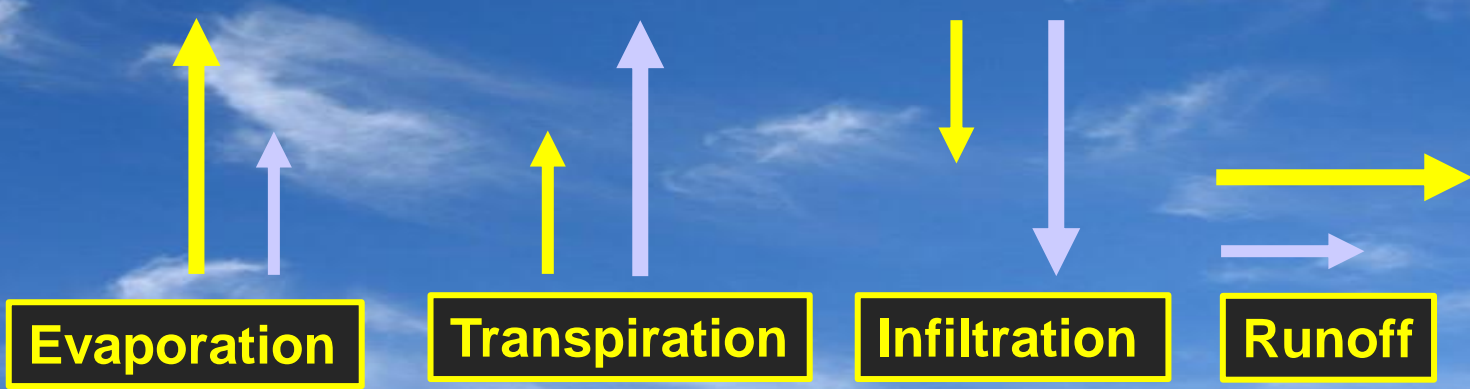
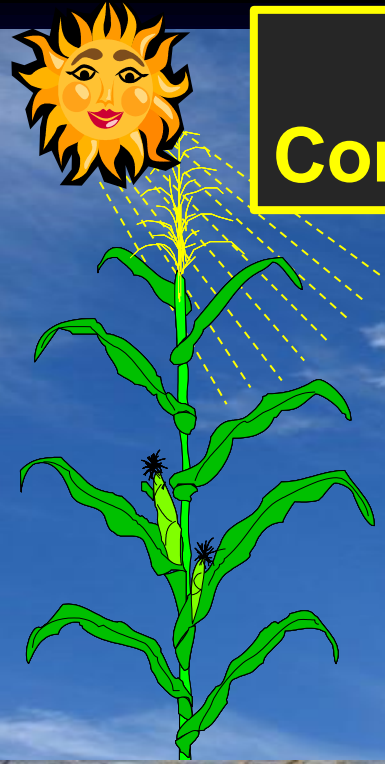
Stairway to Enhanced Water Use Efficiency



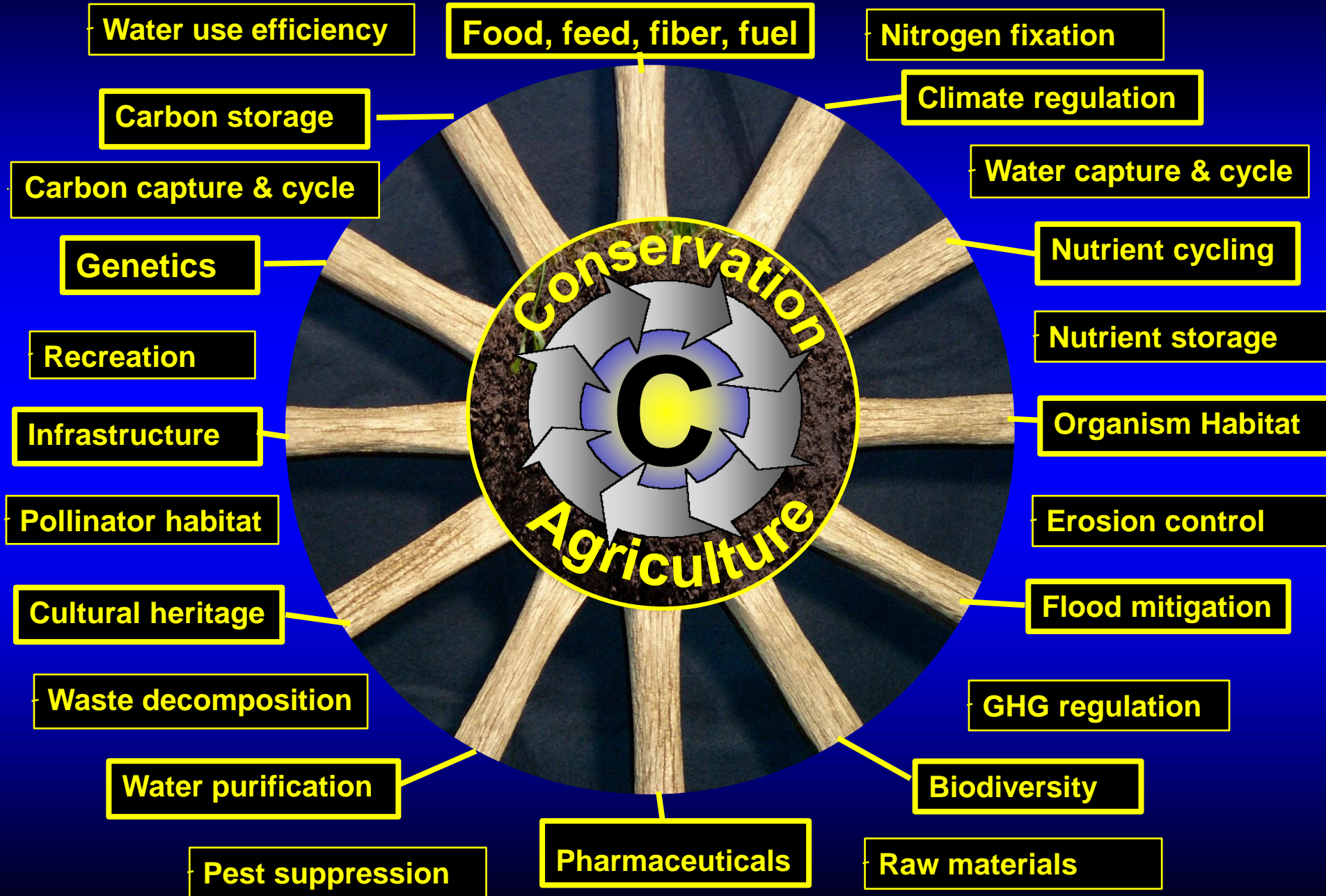
Water Use Efficiency

Conventional Ag

Conservation Ag

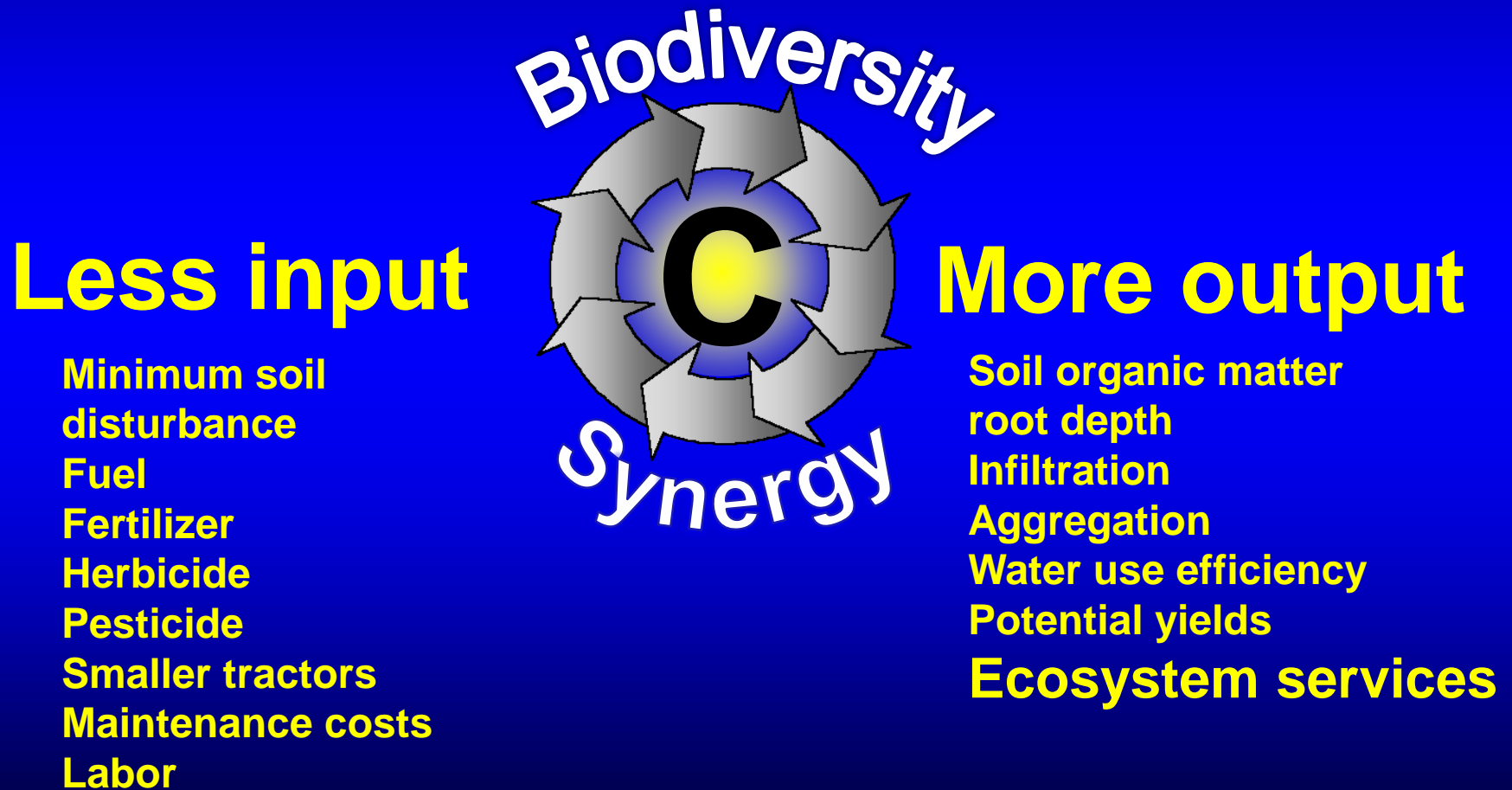


Carbon → CAS → Ecosystem functions



Conservation Agriculture Systems

Nature's Way – “Less = More”



**Our soils contain “living biological partners”
enabling carbon and nutrient cycling synergies
critical to agricultural ecosystem services.**

**Soil degradation is caused by
one word:**

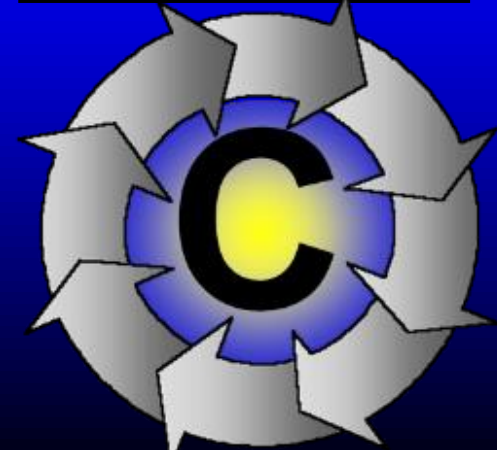
Tillage

**Soil recovery/regeneration is
accomplished by one word:**

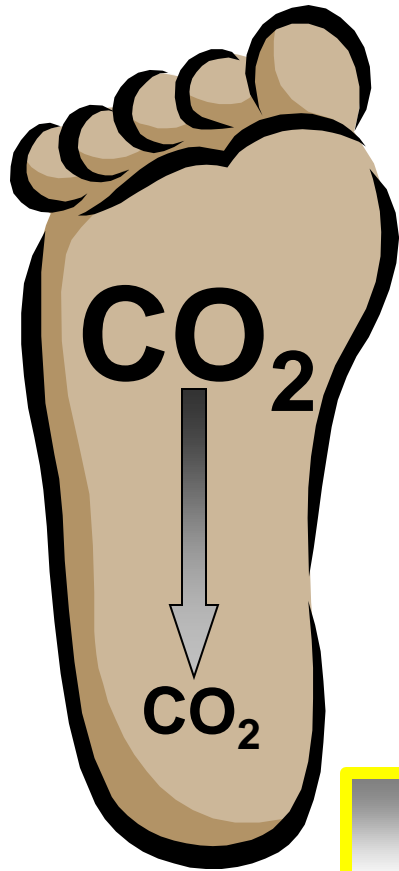
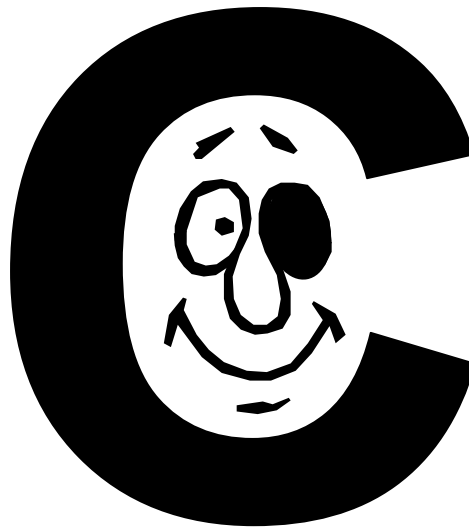
Carbon

**Soil health maintenance is
accomplished by one word:**

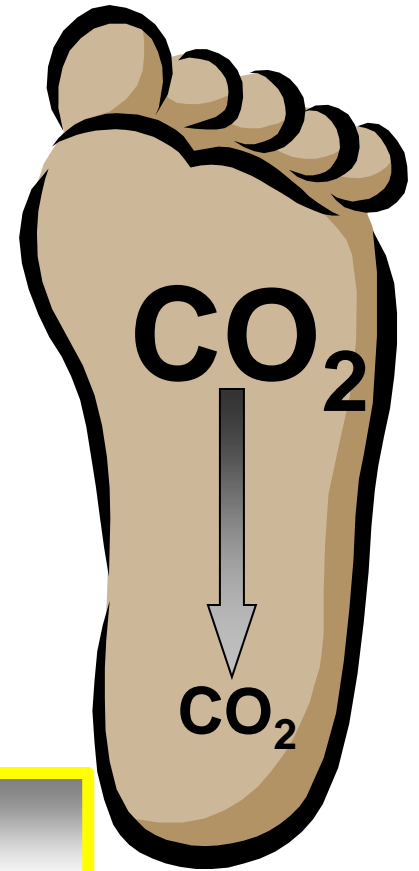
Carbon



Carby Carbon



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



**Conservation Agriculture is a
blueprint of regenerative
agriculture for ecosystem services.**

