CROP CULTIVATION AND PLANT REMEDIATION

The fundamentals

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LaRSSA
LAND REHABILITATION SOCIETY OF SOUTHERN AFRICA

THE FUNDAMENTALS

How to prepare soil for the effective growth of plants

Water management for plants

Challenges for growing plants on contaminated soil

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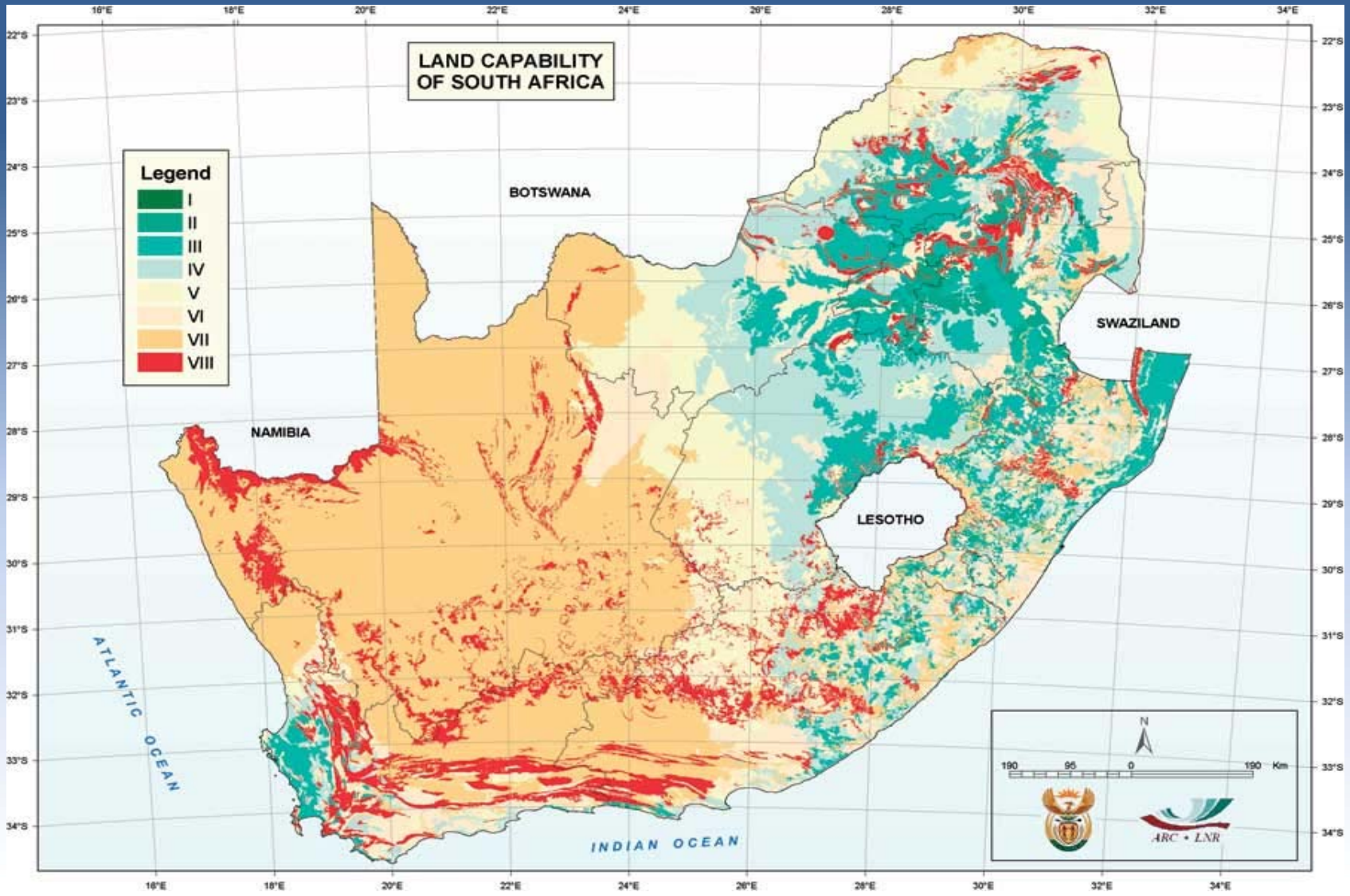

Land capability classes of South Africa

Types of Land Degradation

AGRICULTURE

Types of Land Degradation

MINING

Types of Land Degradation

MINING

Types of Land Degradation

AGRICULTURE / CONSERVATION

Types of Land Degradation

AGRICULTURE / CONSERVATION

DEGRADED / CONTAMINATED LAND

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UNDERSTANDING ECOSYSTEM FUNCTION !!!!

WHAT IS ECOSYSTEM FUNCTION ???

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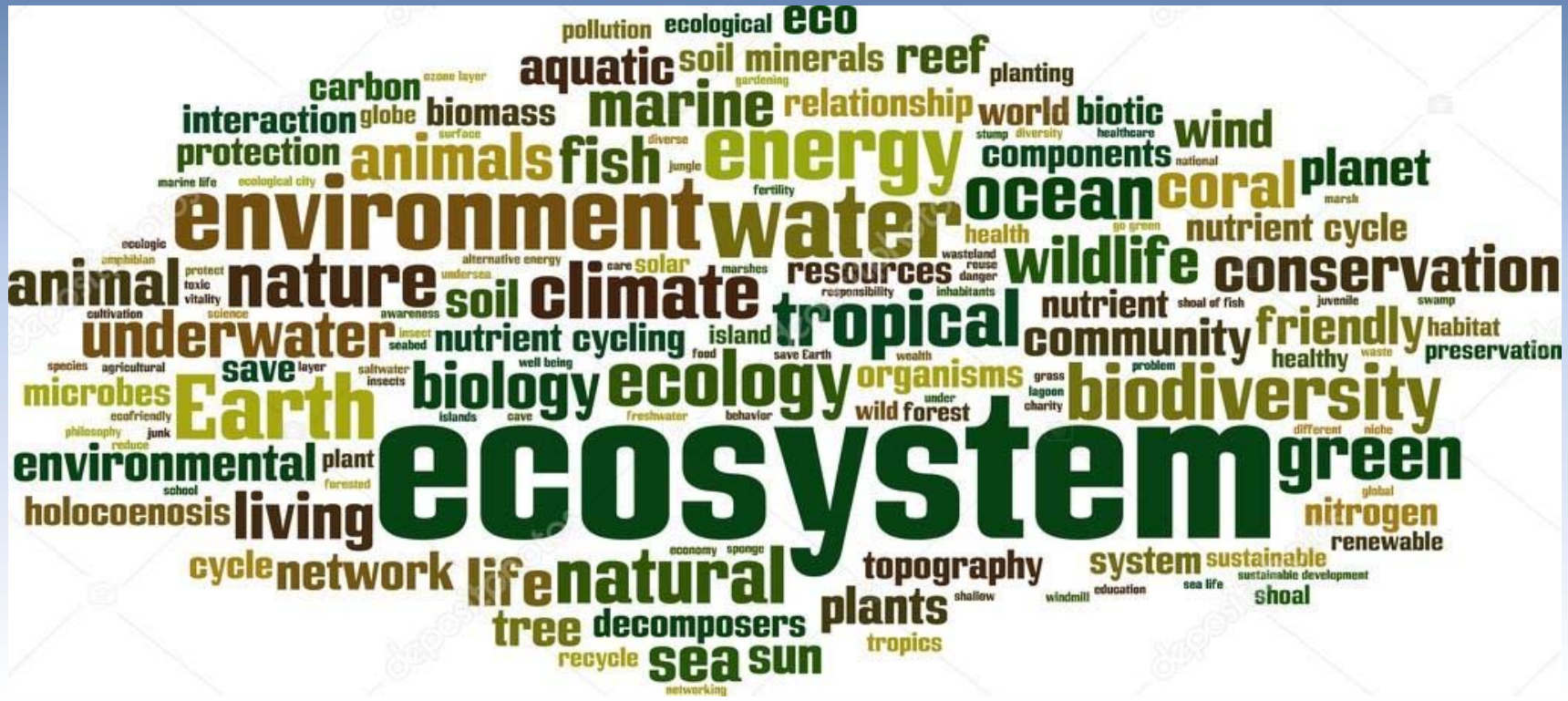
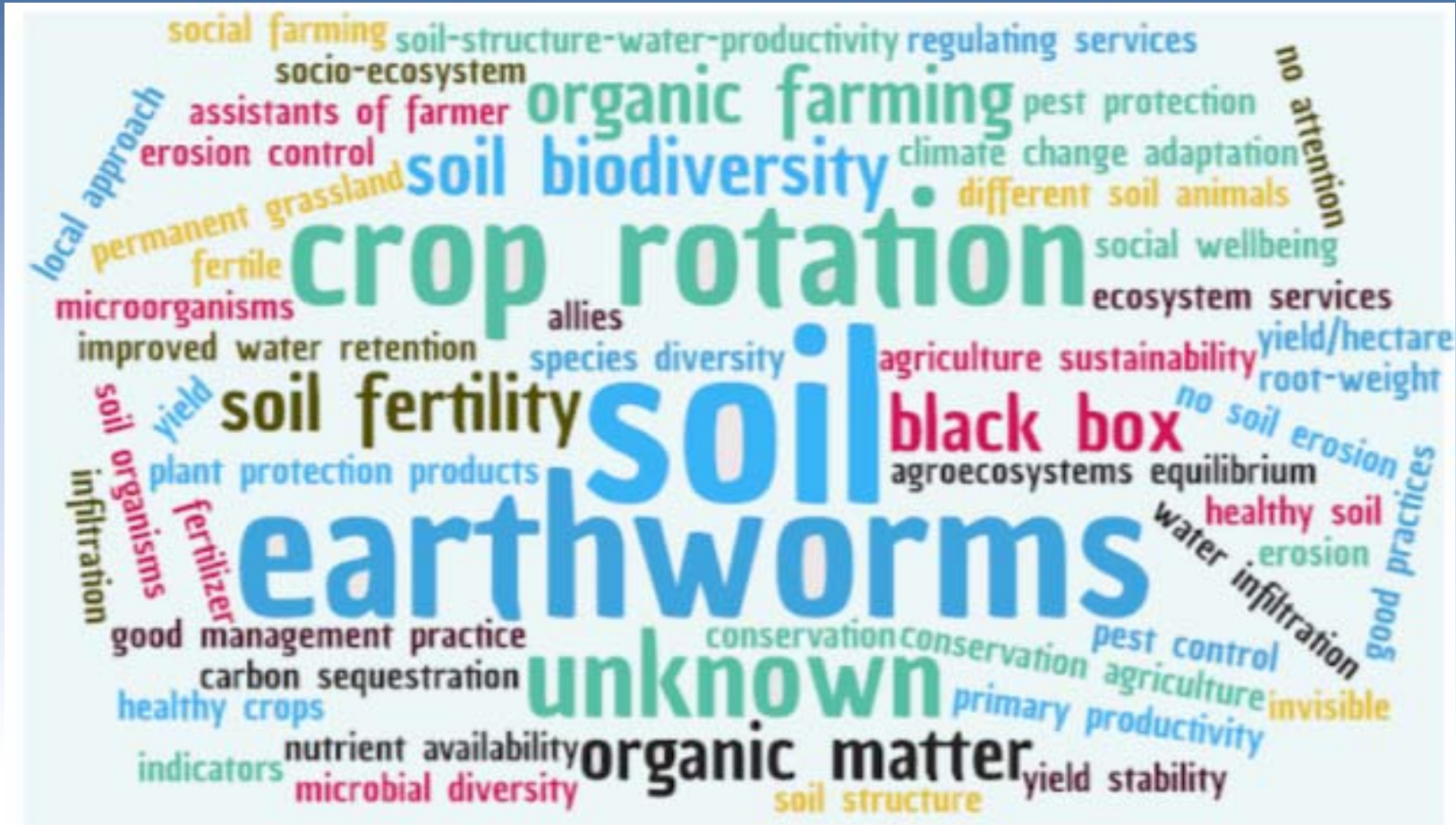
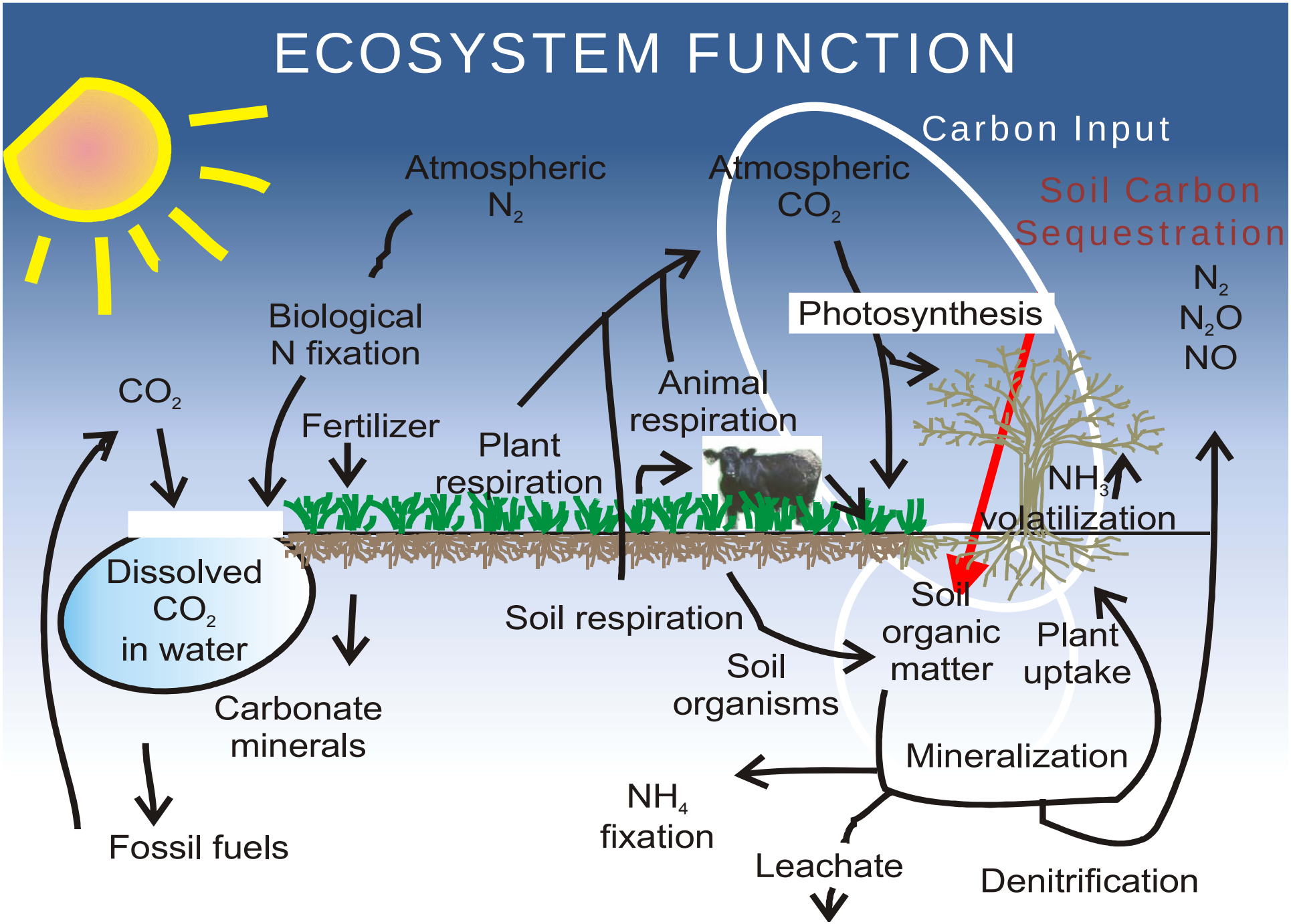
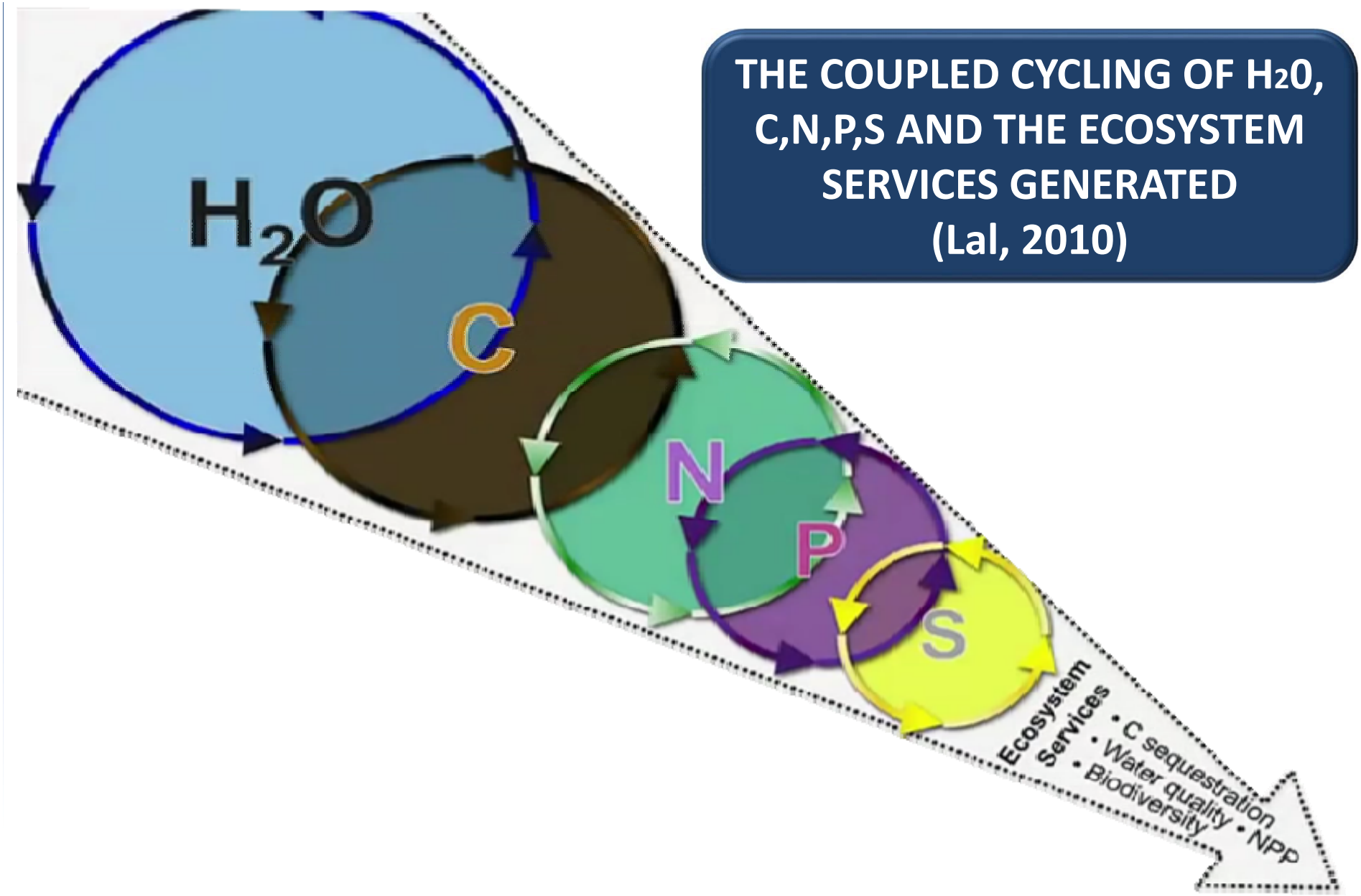


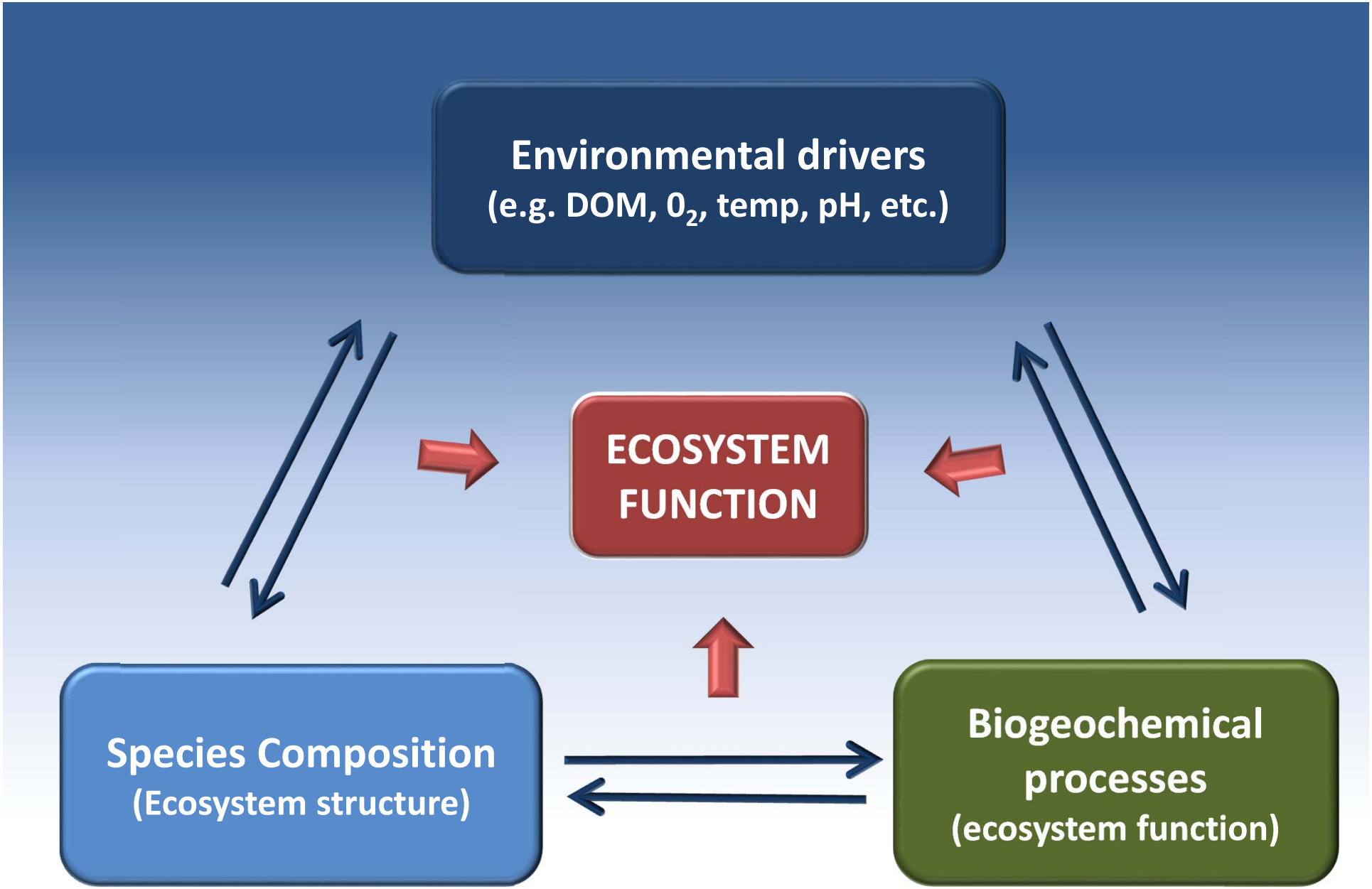
WHAT IS AGROECOSYSTEM FUNCTION ???

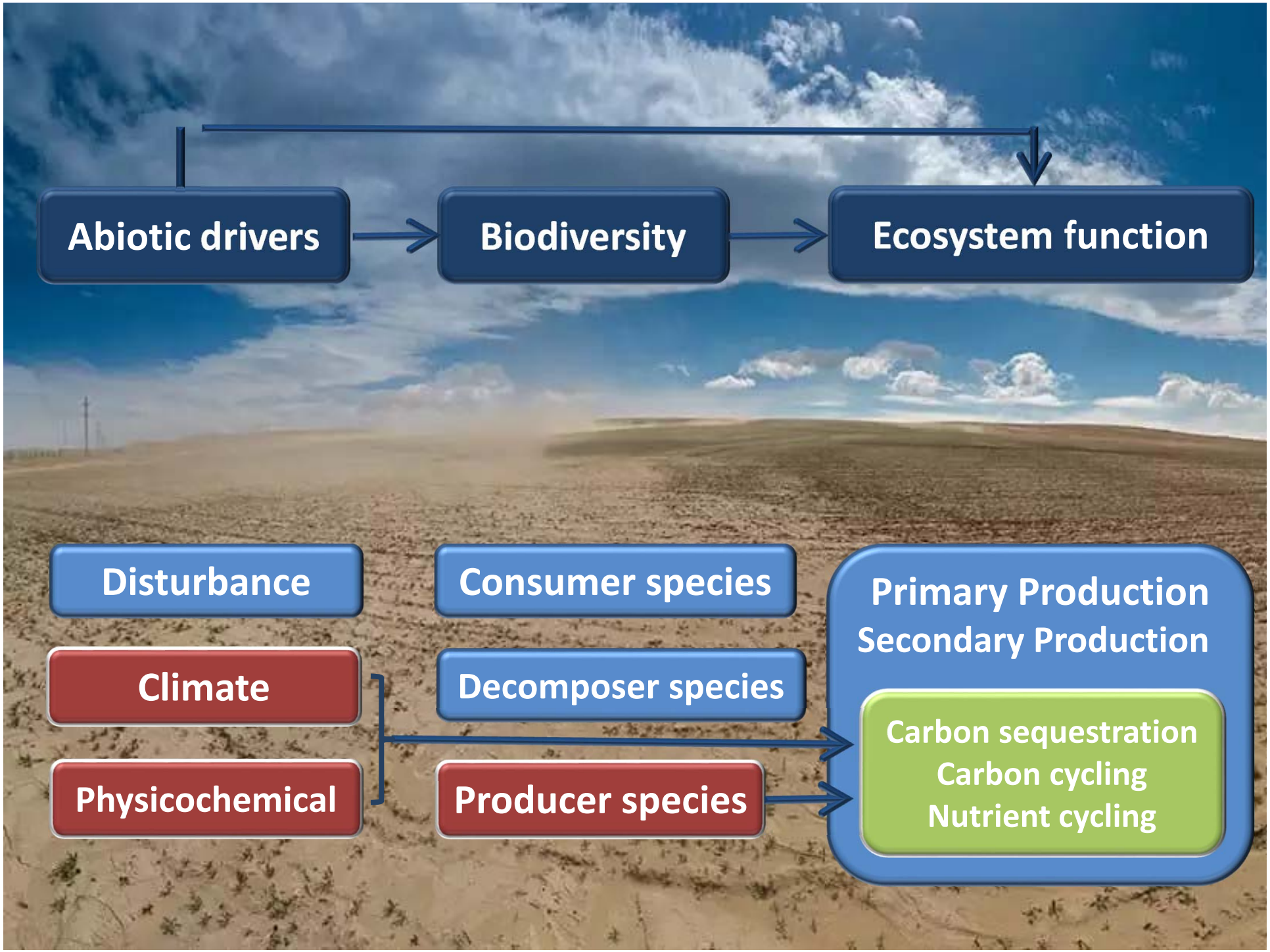



ECOSYSTEM FUNCTION
Carbon Input
Soil Carbon Sequestration
Atmospheric N_2
Atmospheric CO_2
Biological N fixation
Photosynthesis
N_2
N_2O
NO
CO_2
Fertilizer
Plant respiration
Animal respiration
NH_3 volatilization
Dissolved CO_2 in water
Soil respiration
Soil organic matter
Plant uptake
Soil organisms
Carbonate minerals
Mineralization
NH_4 fixation
Fossil fuels
Leachate
Denitrification

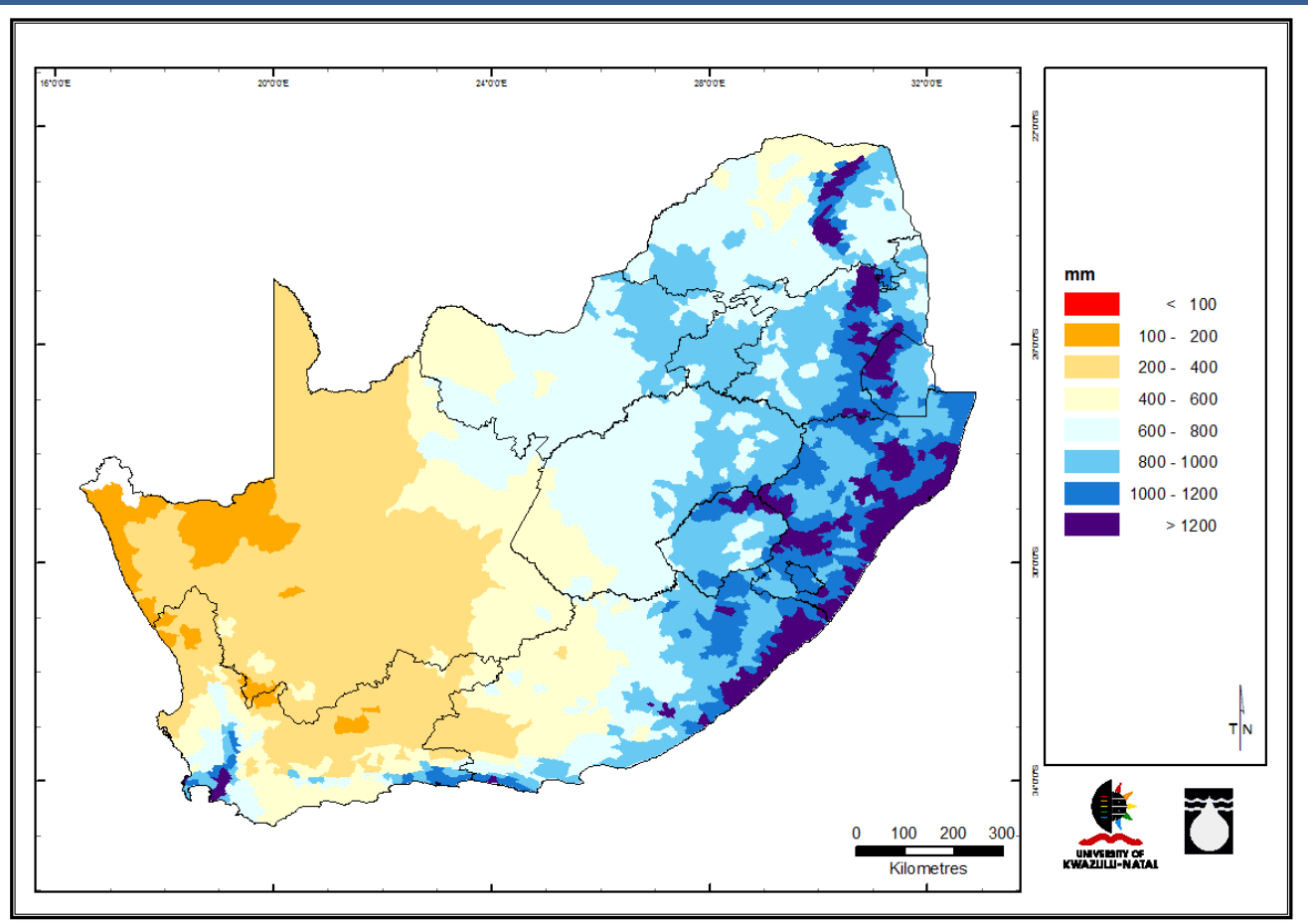
THE COUPLED CYCLING OF H_20, C,N,P,S AND THE ECOSYSTEM SERVICES GENERATED (Lal, 2010)



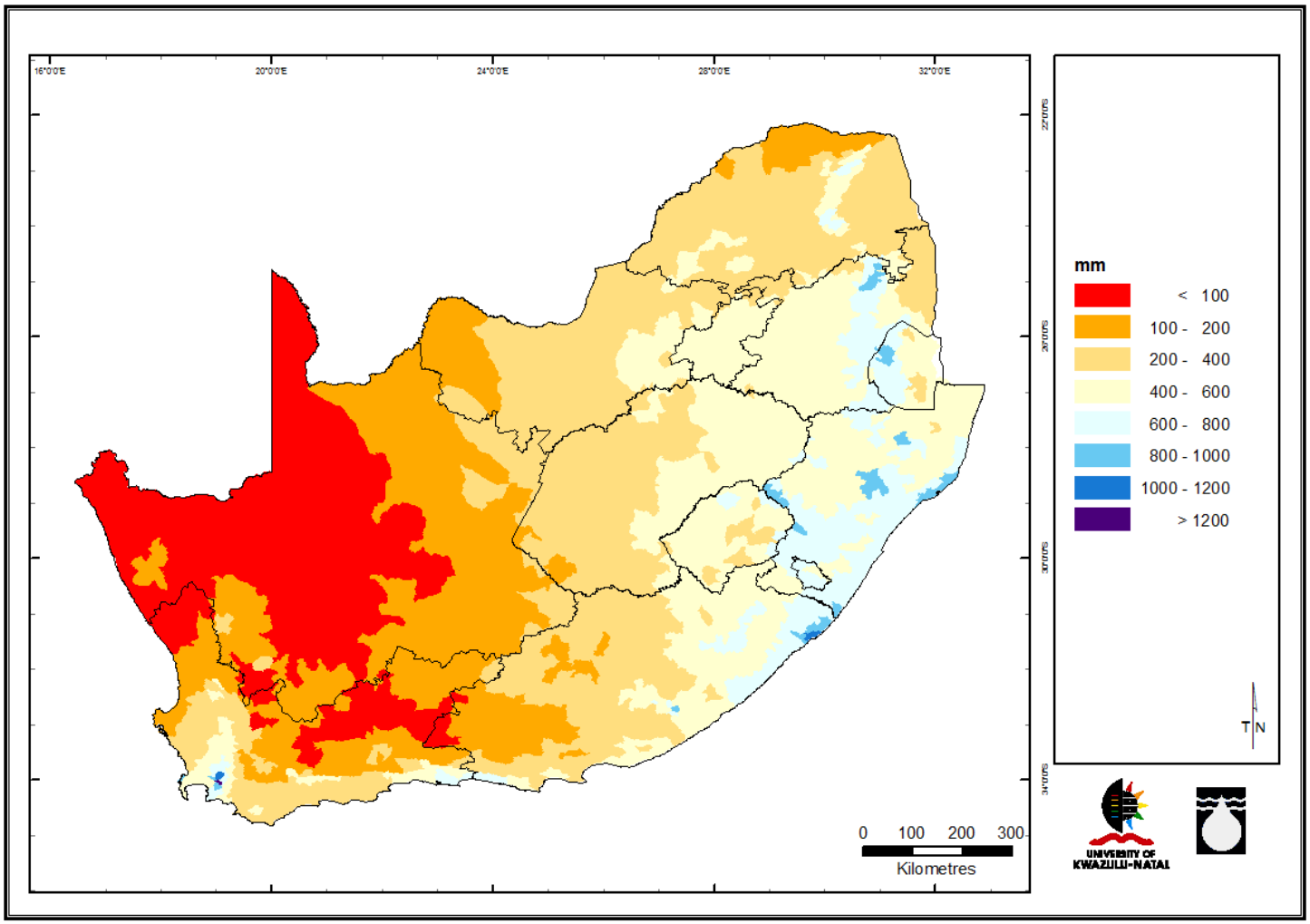



Abiotic drivers
Biodiversity
Ecosystem function
Disturbance
Climate
Physicochemical
Consumer species
Decomposer species
Producer species
Primary Production
Secondary Production
Carbon sequestration
Carbon cycling
Nutrient cycling

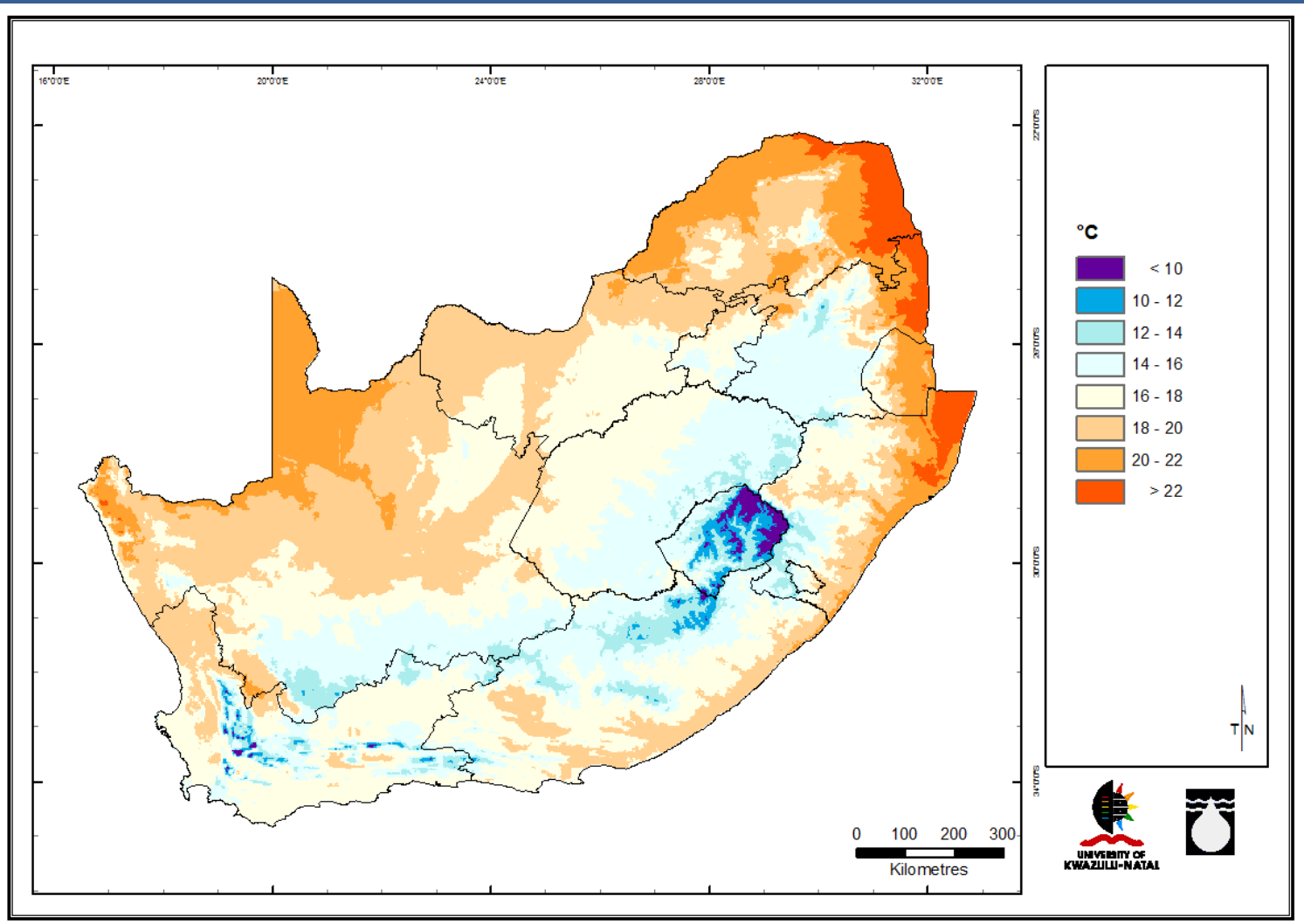
Climate



Mean annual precipitation – wettest year in 10 years

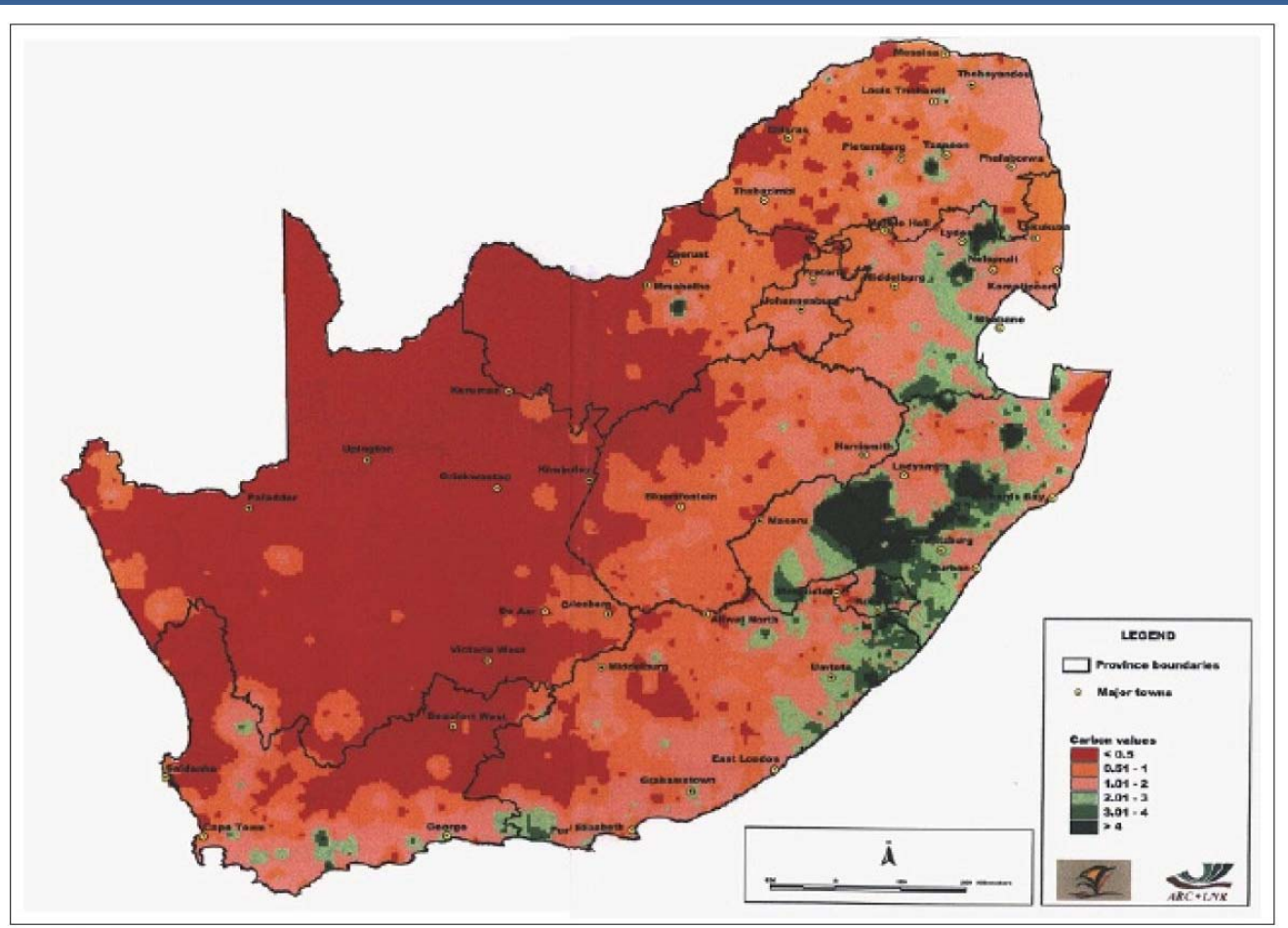


Mean annual precipitation – driest year in 10 years



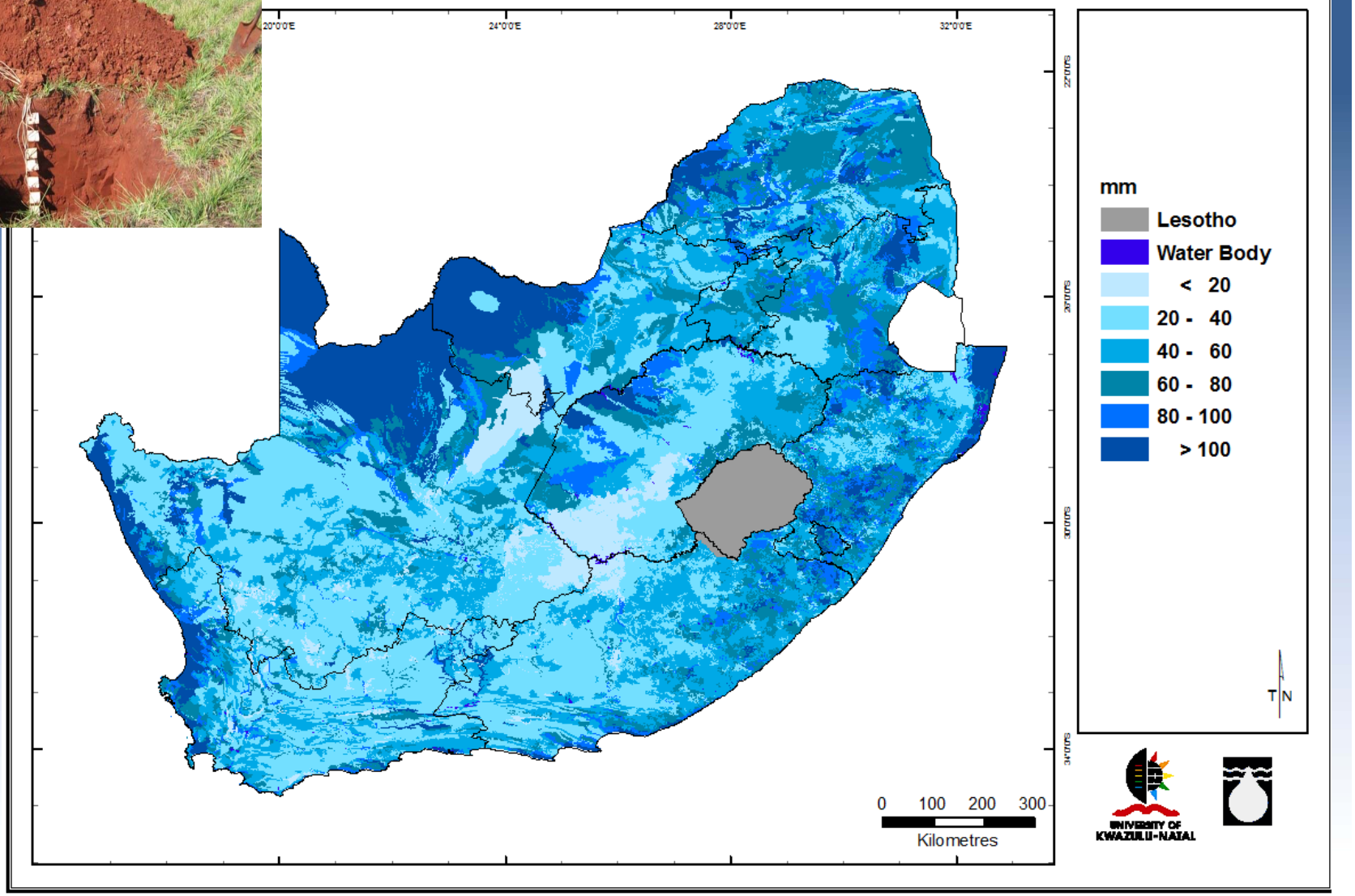
Mean annual atmospheric temp

Physicochemical properties



Source: Barnard[14]

Generalised soil organic carbon of virgin top soils



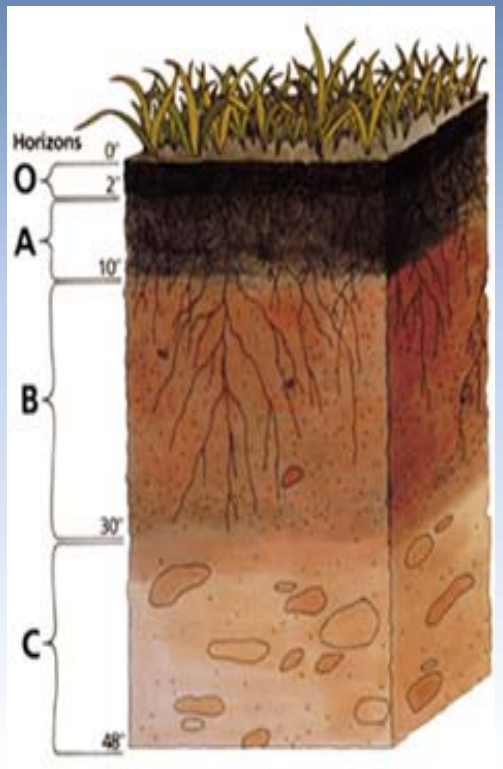
Total depth to plant available water

Land capability classes

SOIL PROPERTIES

PLANT GROWTH RESPONSES

Biomass production
Botanical composition
Basal cover



CHEMICAL

Soil pH
Electrical conductivity
Fertility

PHYSICAL

Bulk density
Infiltration rate
Water holding capacity

BIOLOGICAL

Microbial activity

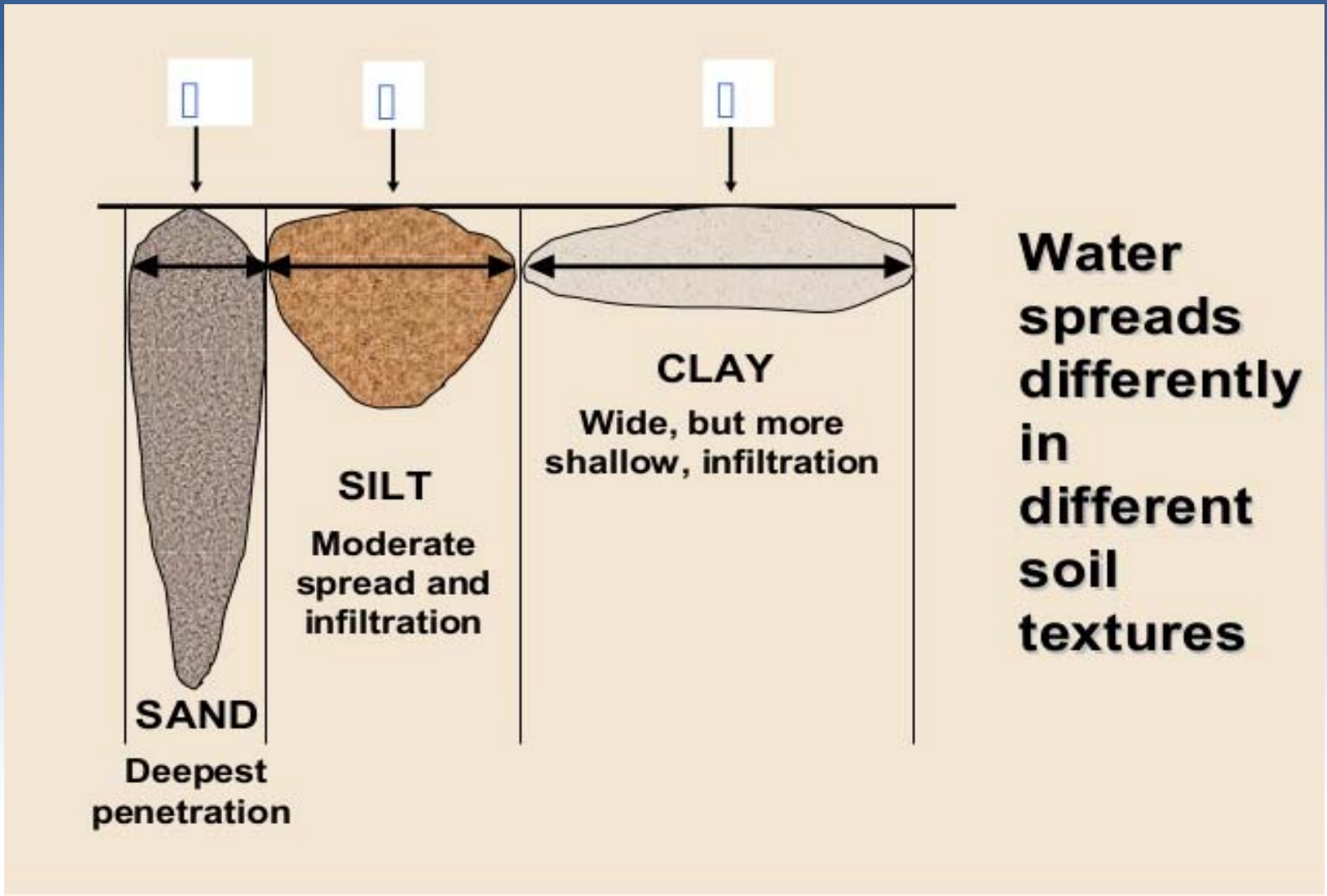
SUSTAINABLE PLANT GROWTH ← **HEALTHIER SOIL**

Soil Handling

Soil preservation

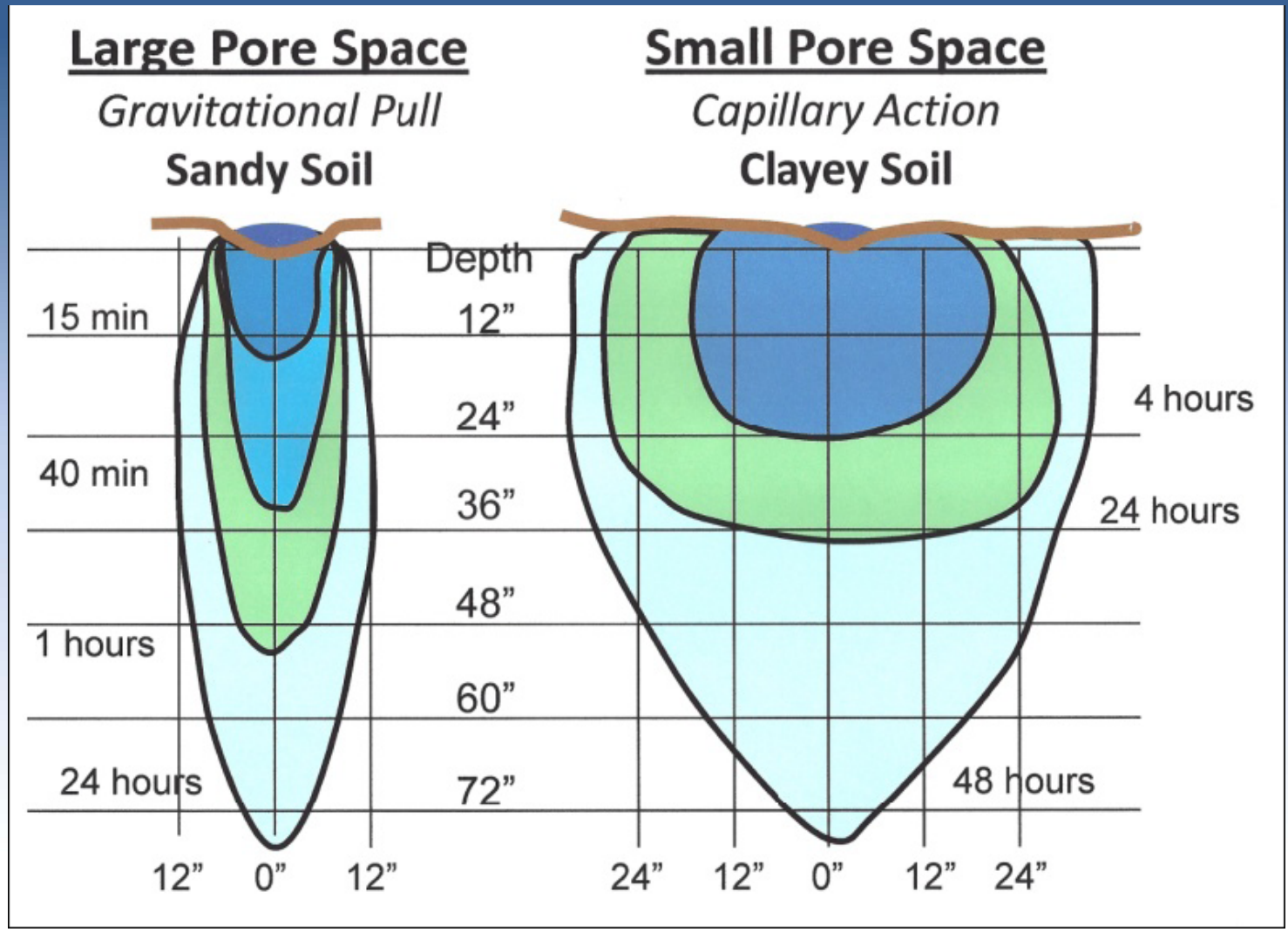
SOIL DYNAMICS

Soil Physical Properties



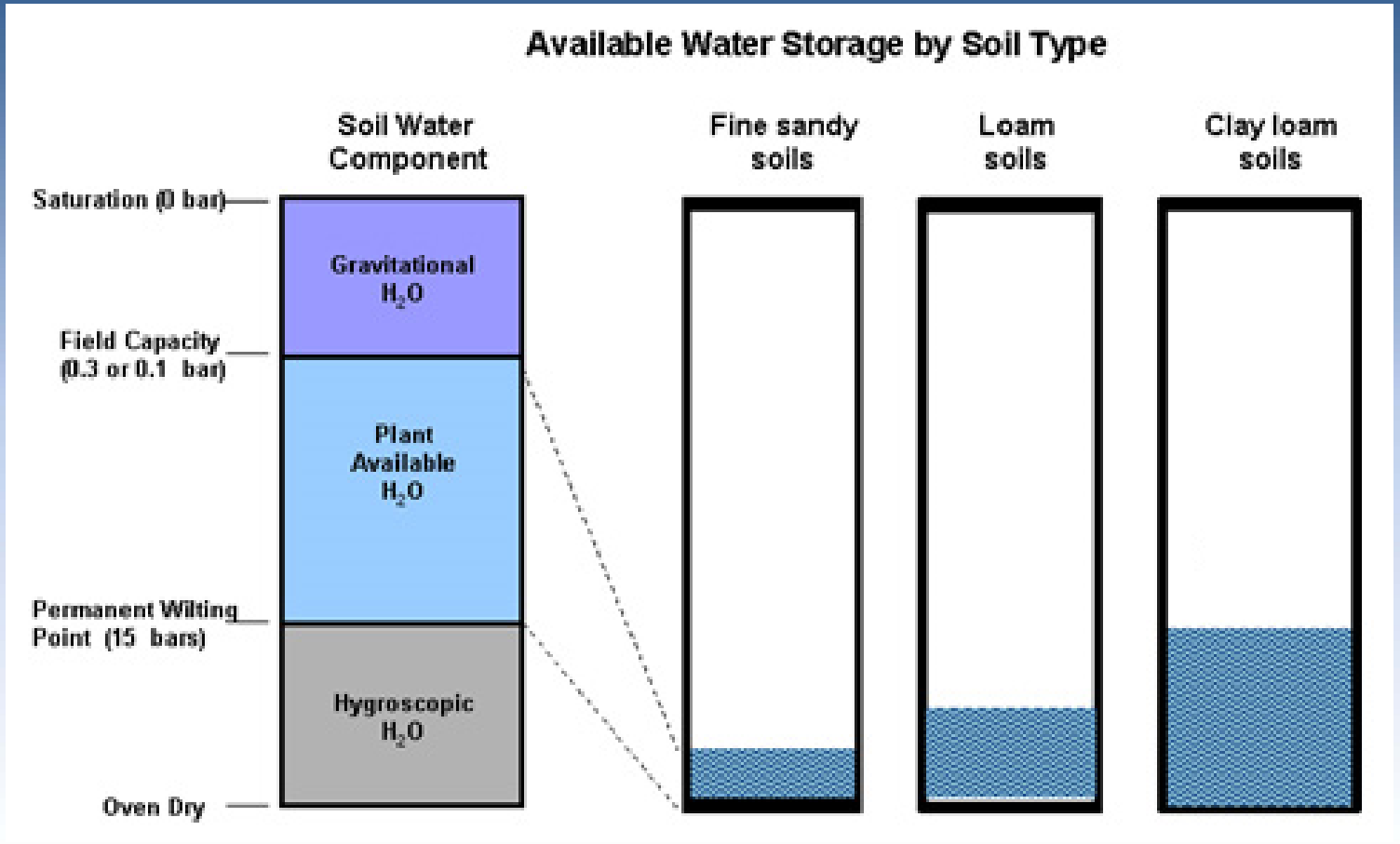
NRCS (USDA)

Water infiltration rate



Soil Science Society of America: *Colorado State Extension*

Soil water holding capacity

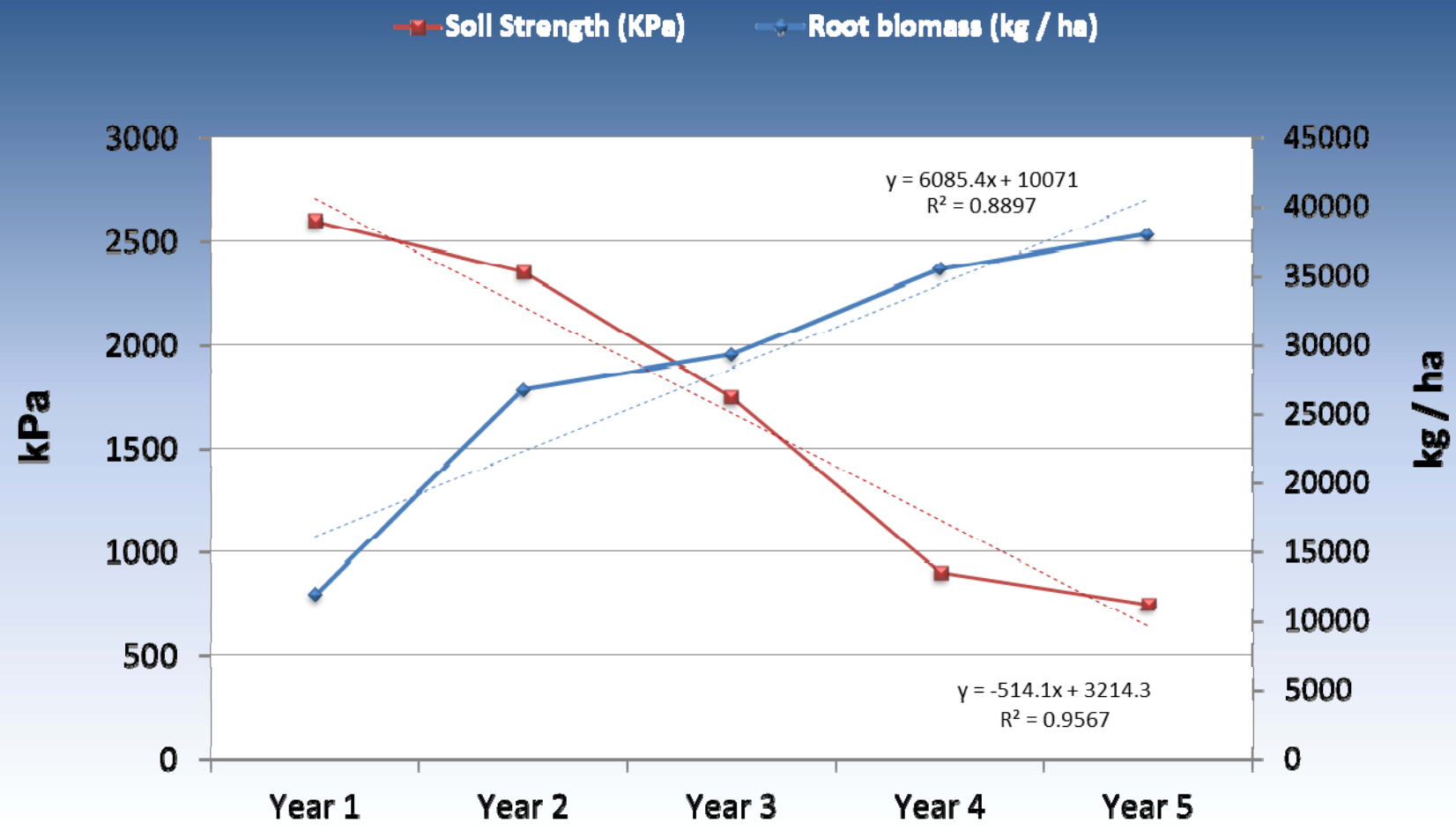


Soil Science Society of America

Soil structure

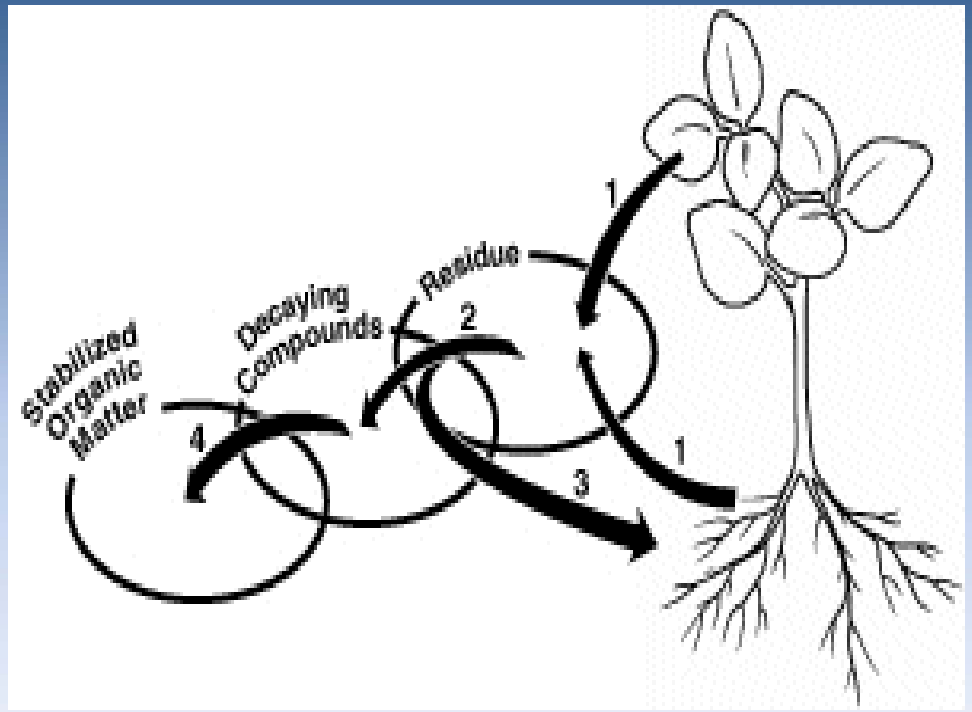
Soil cover / root mass / soil carbon relationships

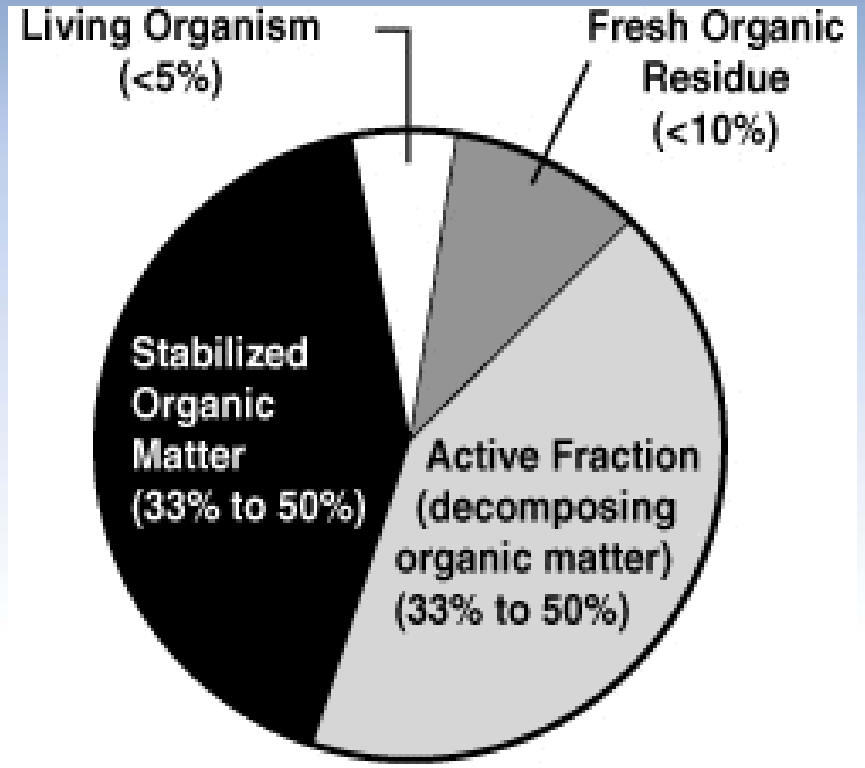
Soil strength

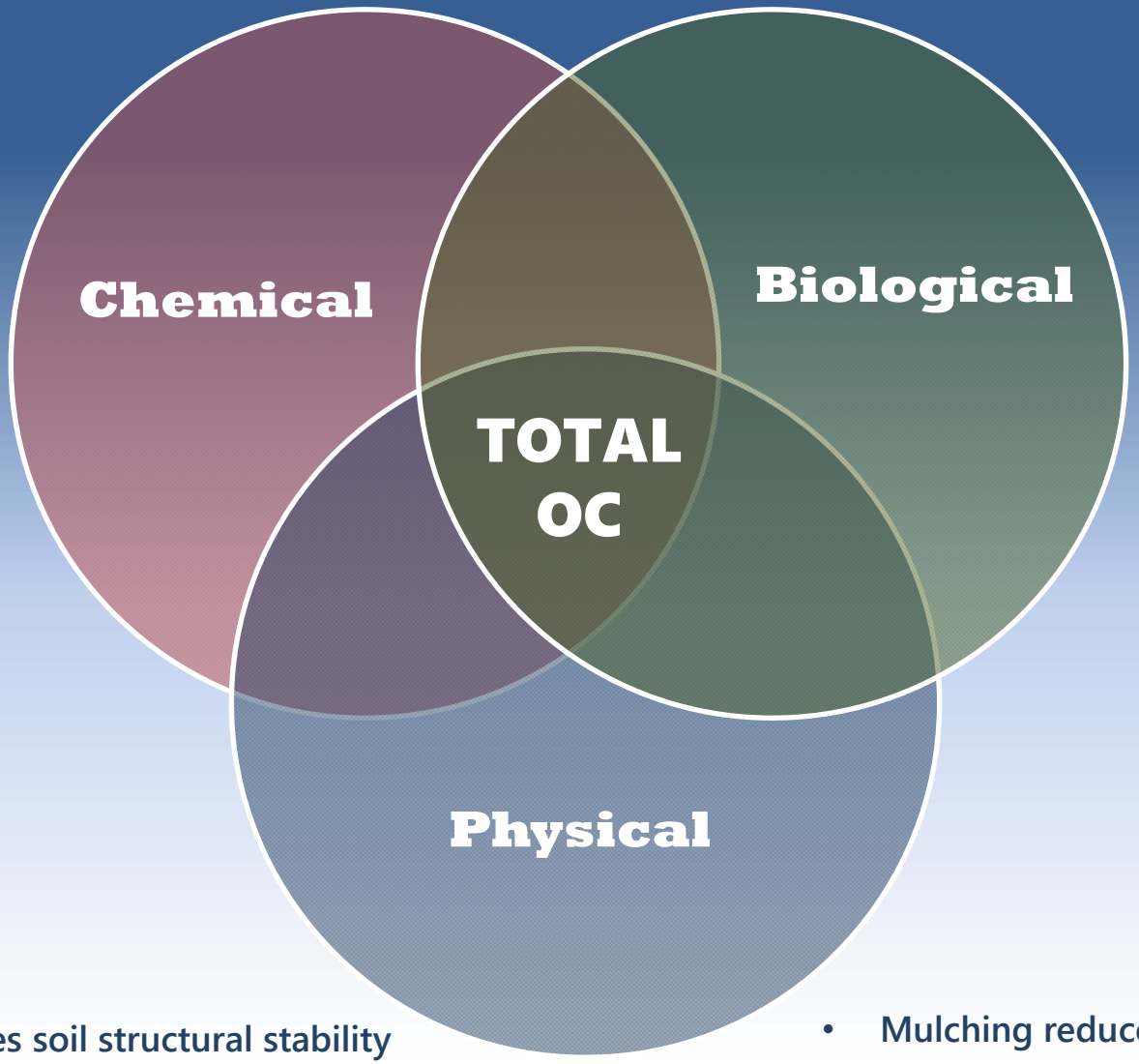


***Digitaria eriantha* (Smutsfinger) pasture**

Soil organic matter / soil organic carbon







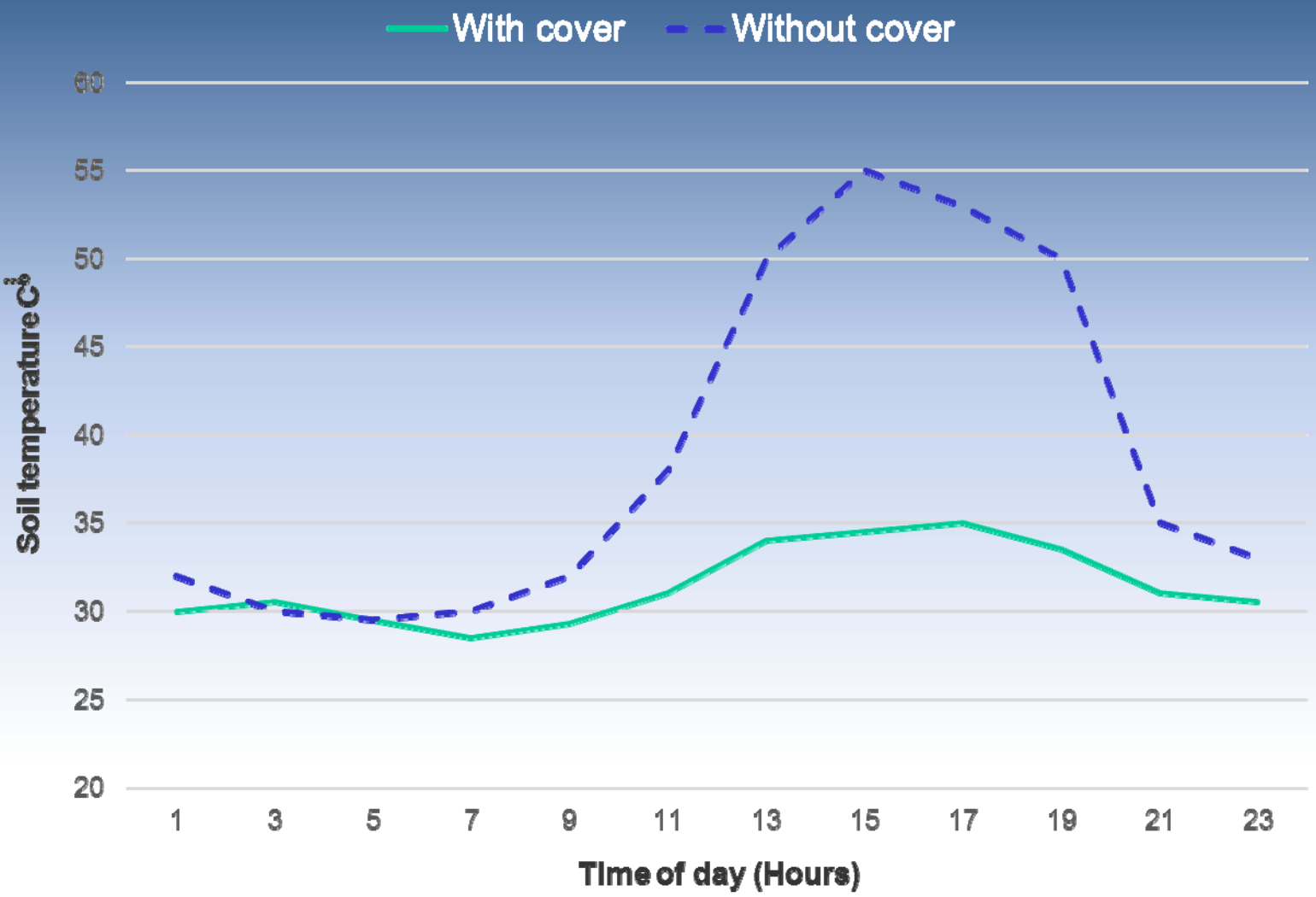
- Buffers pH
- Complexes cations
- Immobilises pollutants
- Binds heavy metals

- Energy for biological processes
- Large storage of nutrients
- Improves soil resilience

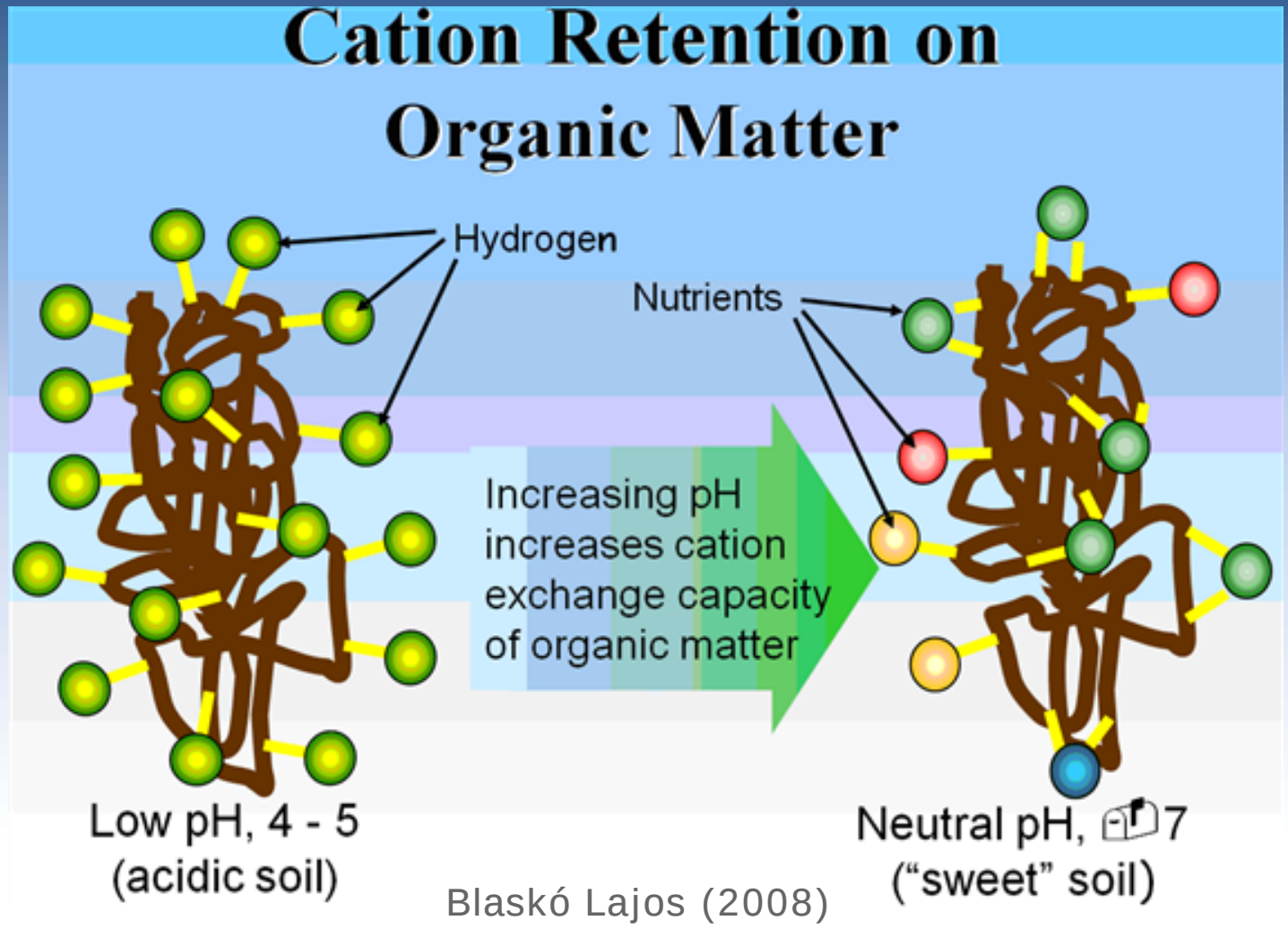
- Improves soil structural stability
- Influences water retention

- Mulching reduces water / soil loss
- Buffers soil temperature

Soil organic matter / Soil temperature relationship

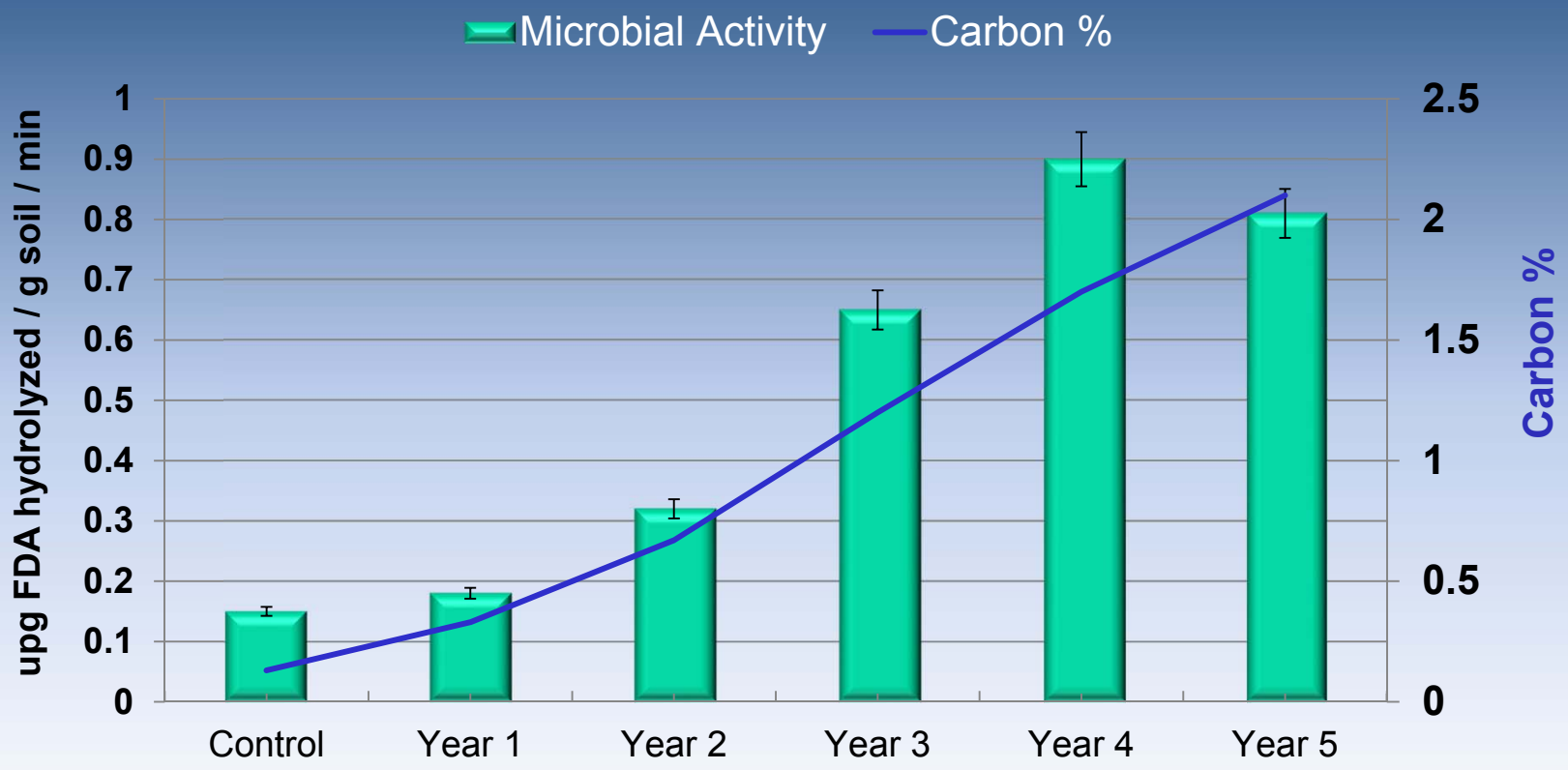


Soil pH / Soil organic matter relationship



Blaskó Lajos (2008)

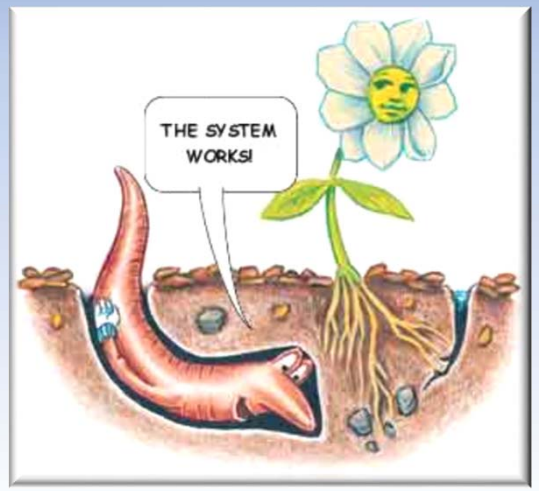
Root mass / Soil carbon / Soil microbial activity relationship



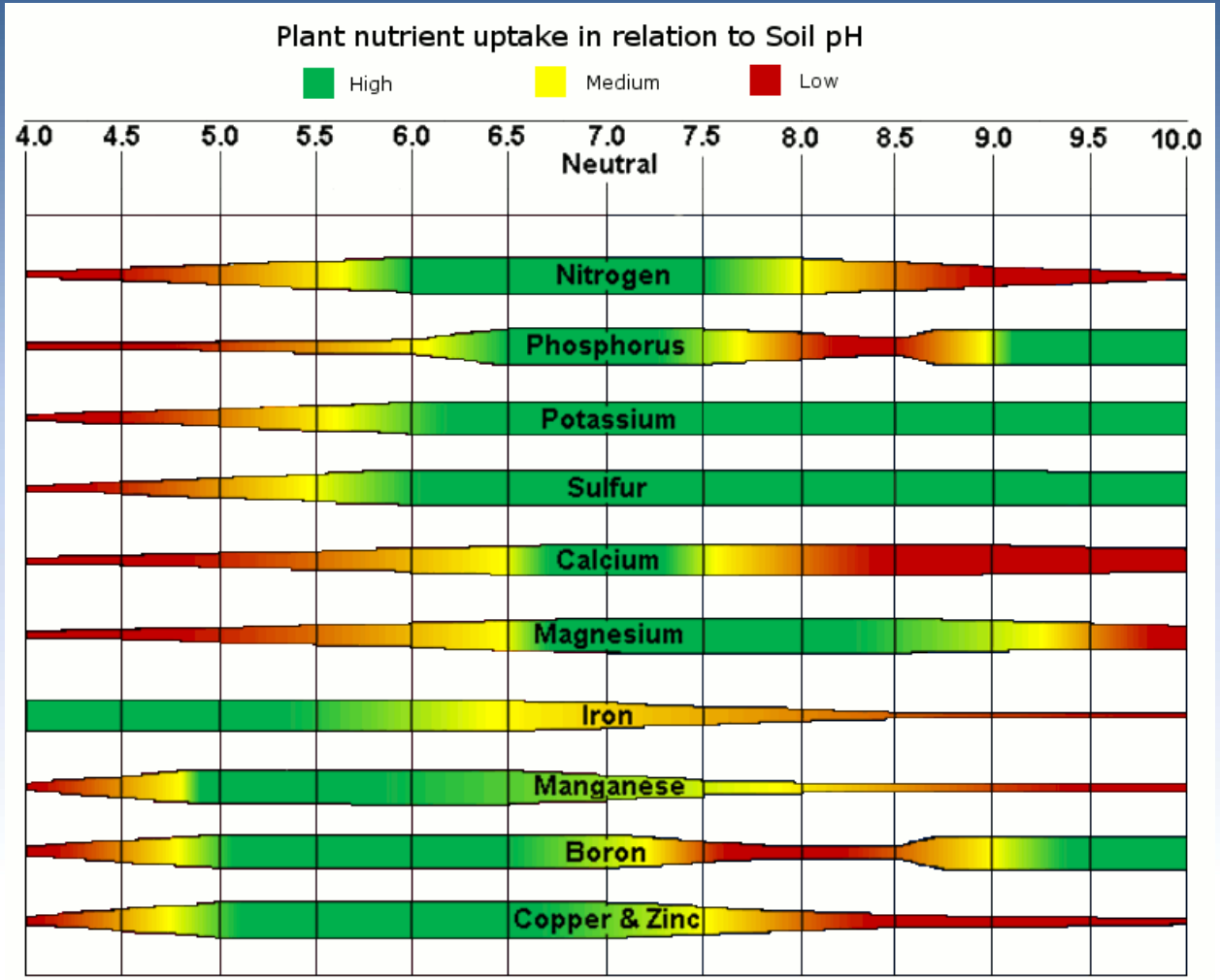
Healthy soil microbiology (i.e. prescence of mychorhiza etc.)

Legumes pastures can fixate between:

75 – 350 kg / Nitrogen ha^{-1}



Soil Chemical Properties



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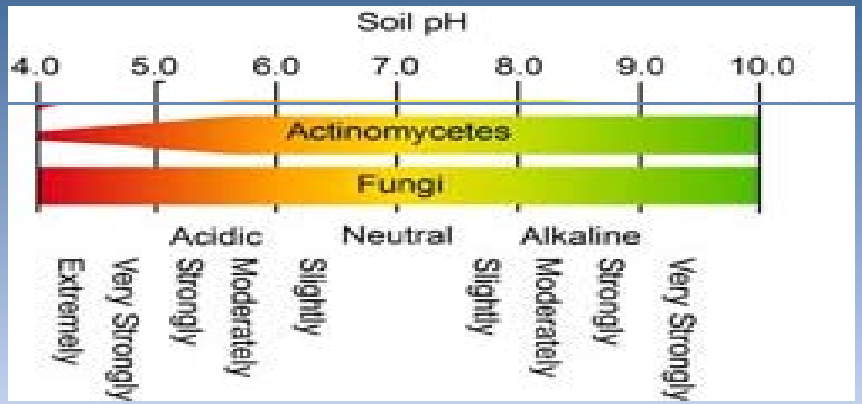
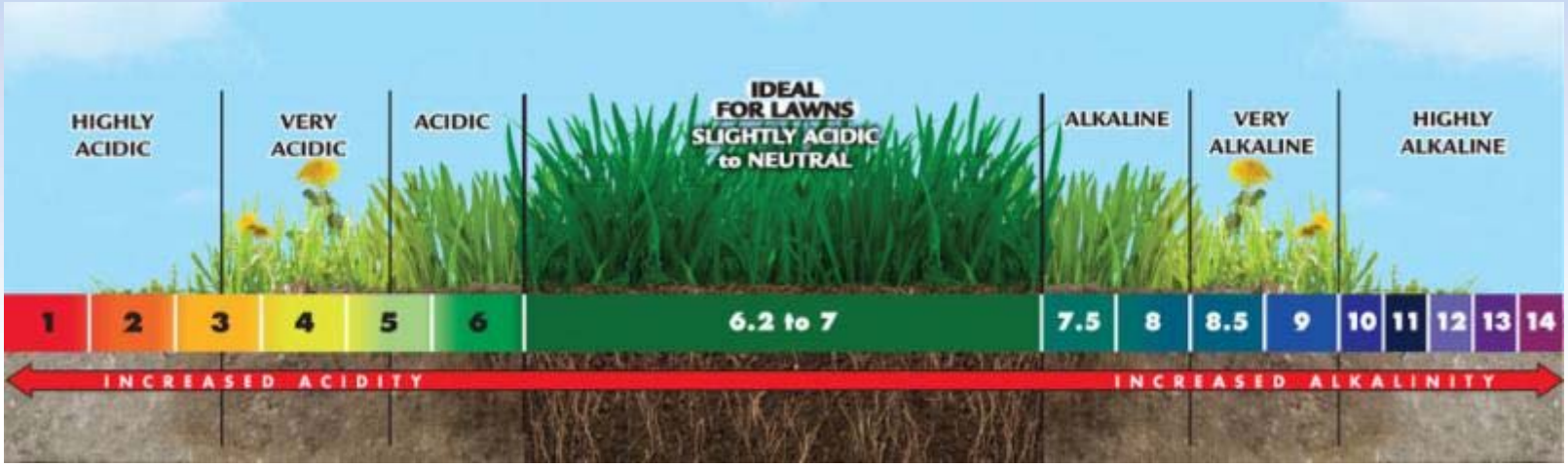




Reclamation practices









Reclamation practice

Soil preparation

Reclamation practice

Landscaping

Soil amelioration






Amelioration Strategies

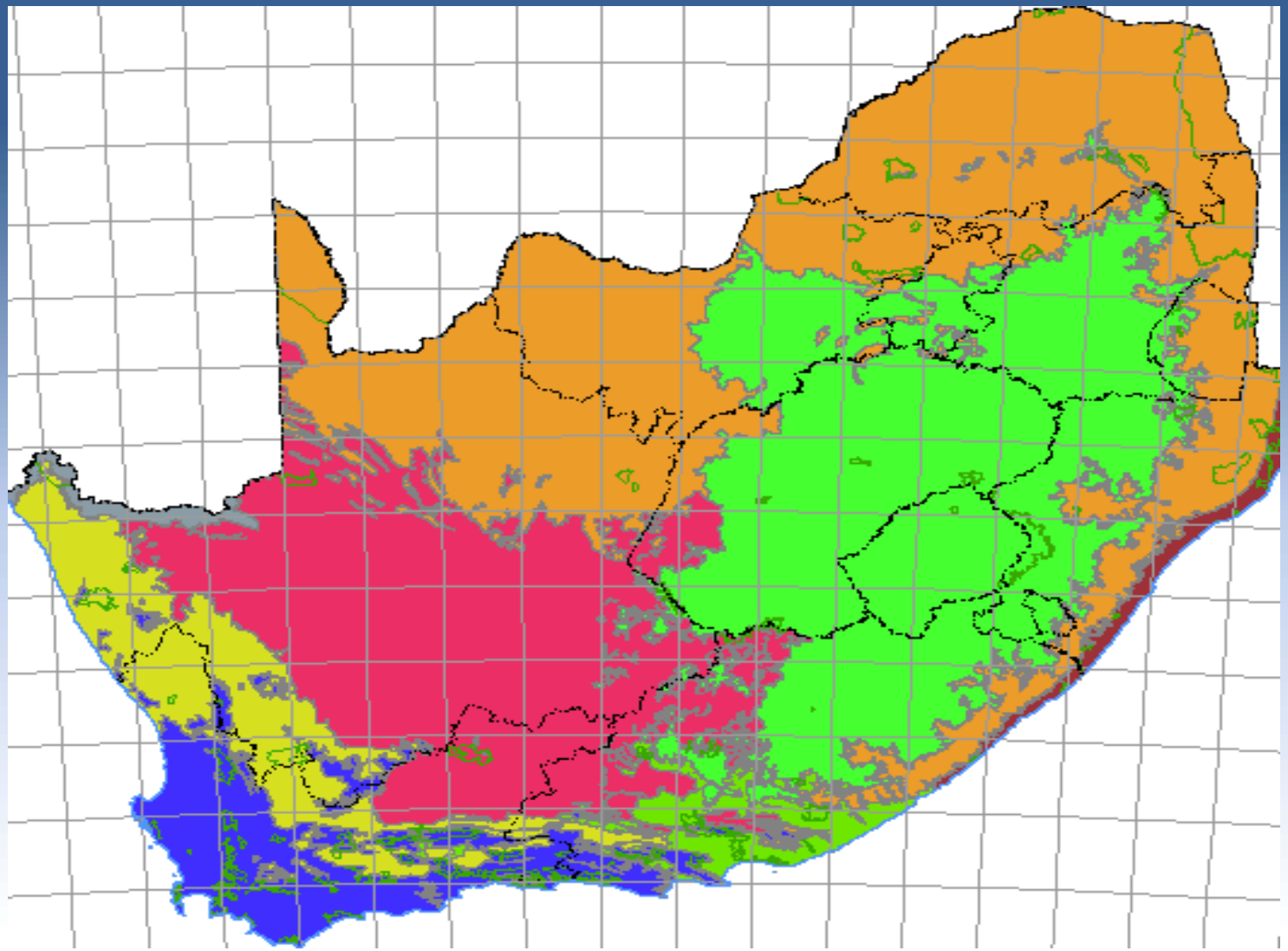
SOIL FACTOR	TREATMENT
Acidic soils	Alkaline treatments
Improve nutrient status	Fertilization
Soil organic matter	Compost / Manuring
Improve bulk density	Compost / Manuring
Relieve compaction	Mechanical ripping
Improve microbial population	Compost / Manuring
Improve microbial population	Improve soil chemical / physical properties

Reclamation practice

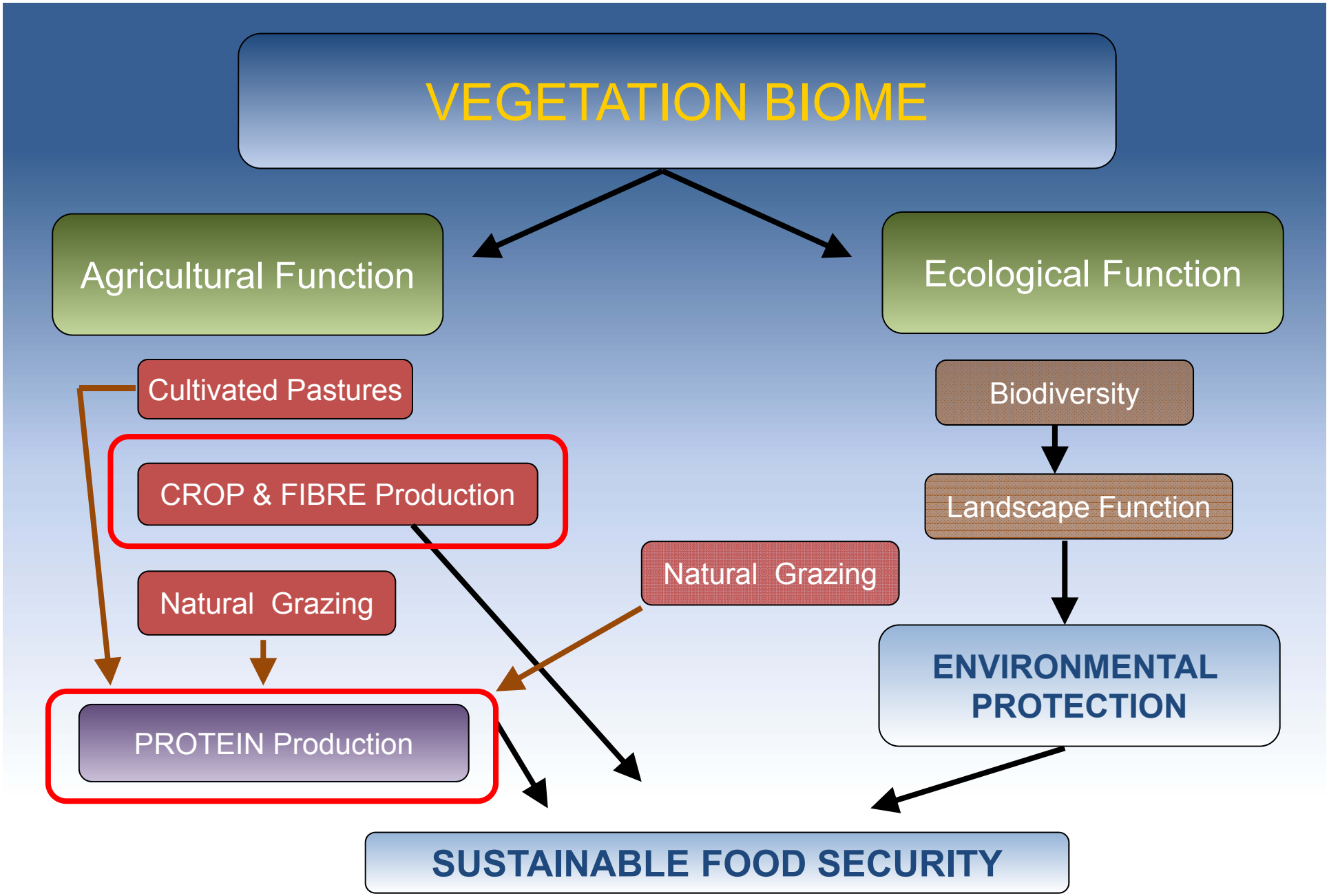
Re-vegetation





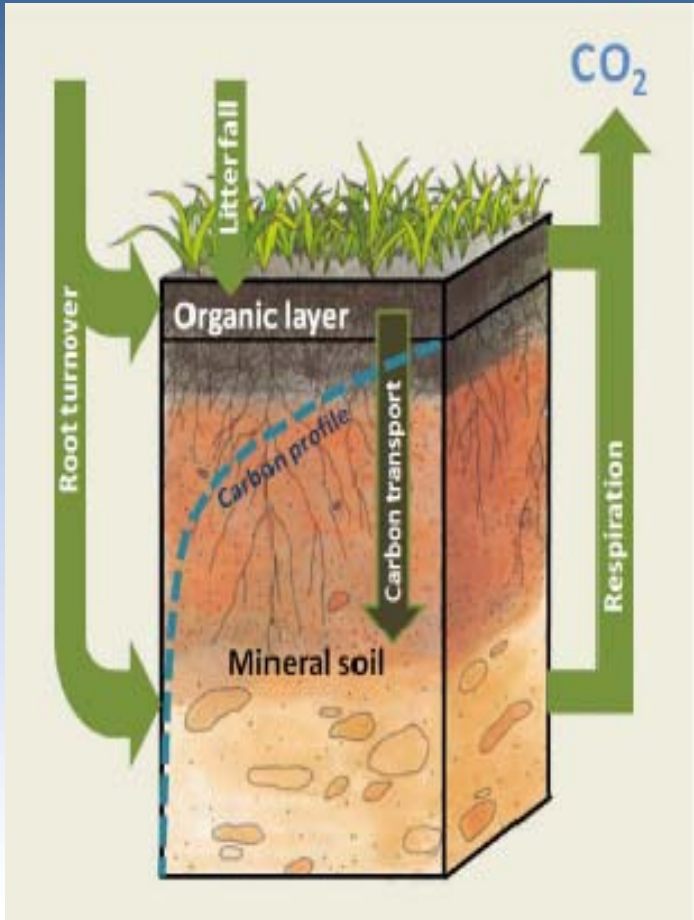



Biomes of South Africa

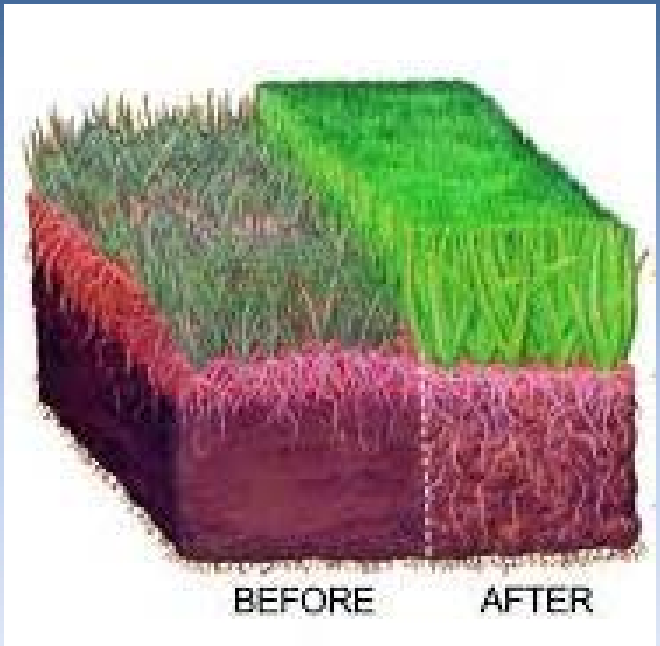


FUNCTION OF VEGETATION

- Improves soil health through:
  - *Providing the soil with*
    - *Organic matter*
    - *Above ground (Litter / green manure)*
    - *Below ground (Roots)*
    - *Nutrients*
    - *Food for micro organisms – (improving nutrient use efficiency)*



FUNCTION OF VEGETATION



- **Alleviates surface crusting / compacted underground layers *(Deep rooted crops)***
- **Soil moisture conservation**
  - Better infiltration
  - Less evaporation

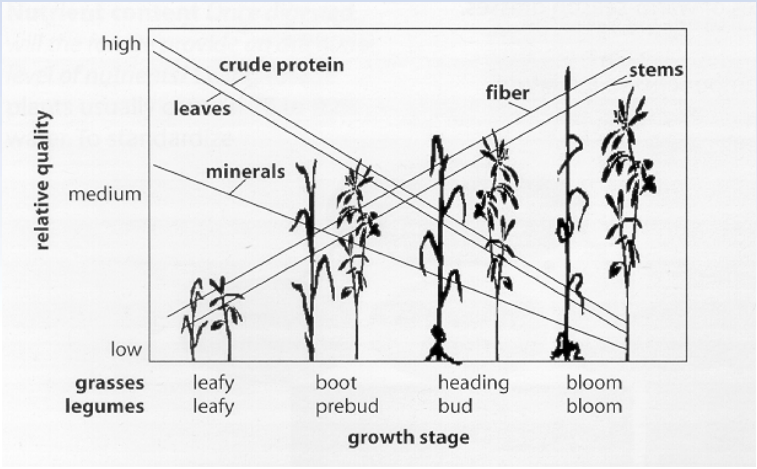
- Good quality roughage / green manure production
- Weed control

FUNCTION OF VEGETATION

- Slope Stabilization
  - Deep rooting vegetation
  - Vigorous root systems
- Surface stabilization
  - Creeping species
  - Vigorous root systems
- Waterways (drainage channels)
  - Creeping species
  - Tolerant of waterlogged periods

Revegetation

- **Factors that contribute to stand failure**
  - *Seedbed not fine enough*
  - *Depth of sowing (to deep or to shallow)*
  - *Time of sowing*
  - *No rolling*
  - *To much fertilizer (seed burn)*
  - *Poor quality seed*
  - *Low seeding rate*
  - *Poor soil condition (acid soils)*
  - *Seed coat maybe*
    - *Impenetrable for water and oxygen*
    - *To hard for seedling to get through*
  - *Seed maybe to fresh*
  - *Germination inhibiting substances present*
  - *Not enough oxygen in the soil*
  - *Temperature unfavorable*
  - *Crust formation*



Revegetation - Seeding

- **Factors determining seeding success**
  - *Seed size*
  - *Weight of seed*
  - *Seed form – light fluffy seeds*
  - *Growth form of plant*
  - *Method of seeding*
  - *Row spacing*
  - *Seed viability (Germination %)*
  - *Purity of seed (certified)*
  - *Planting objective*
  - *Irrigation*
  - *Soil moisture content*
  - *Seedbed condition*
  - *Soil fertility*

Revegetation

- **Factors that determine when to revegetate**
  - *The crop*
    - *Annuals vs perennial*
    - *Temeperate vs sub-tropical*
  - *Length of growing season*
  - *Lowveld vs Highveld*

    (Height above sea level)
  - *Degree of weed infestation*
  - *Distribution of rainfall*

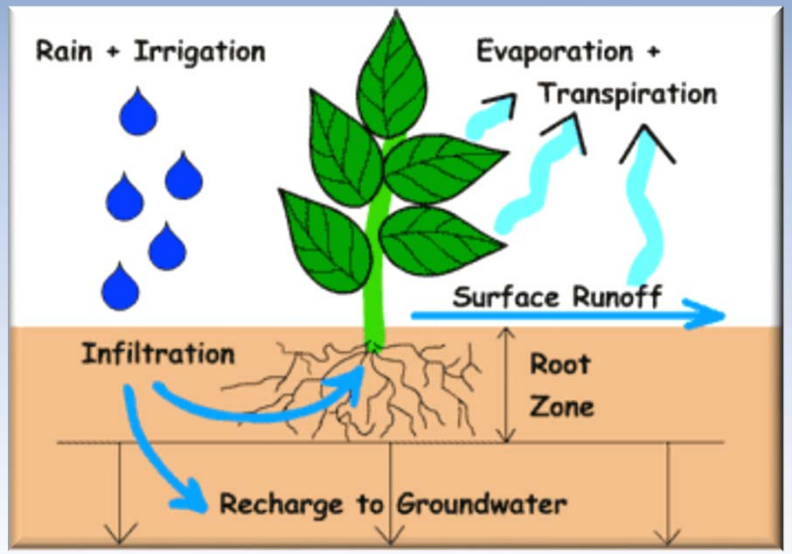
Revegetation

- **Factors that facilitate establishment**
  - *Mulching*
    - *Limits moisture losses*
    - *Creates favourable microclimate*
    - *Prevents crust formation*
    - *Enhances germination*
  - *Nurse / cover crops (Leys)*
    - *Areas with harsh winters, hot summers, weeds*
    - *Annual crops*
    - *Protects young seedling*
    - *Harvest before blocks out light*

Revegetation – Vegetative

Water Management

Soil water balance



$$ET = P + I - R - Dr - \Delta\vartheta$$

(Pennman Monteith Equation)

ET = Evapotranspiration (mm)
P = Precipitation (mm)
I = Irrigation (mm)
R = Runoff (mm)
Dr = Drainage (mm)
Δθ = Difference in soil water content (mm)

CROP WATER REQUIREMENTS

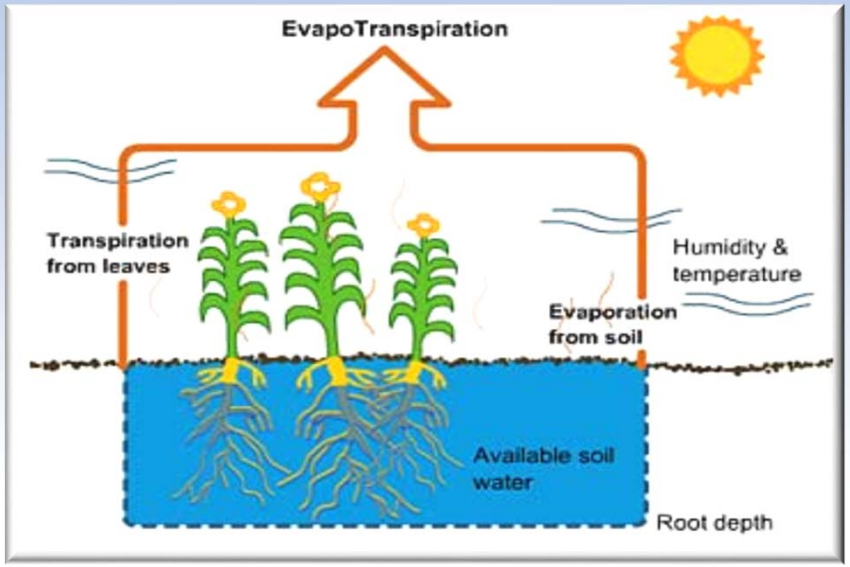
$$ET = K_c \, ET_o$$

Where:

ET_c - crop evapotranspiration [mm d^{-1}]

Kc - crop coefficient [dimensionless]

ET_o - reference crop evapotranspiration [mm d^{-1}]



PAR – Photosynthetic Active Radiation

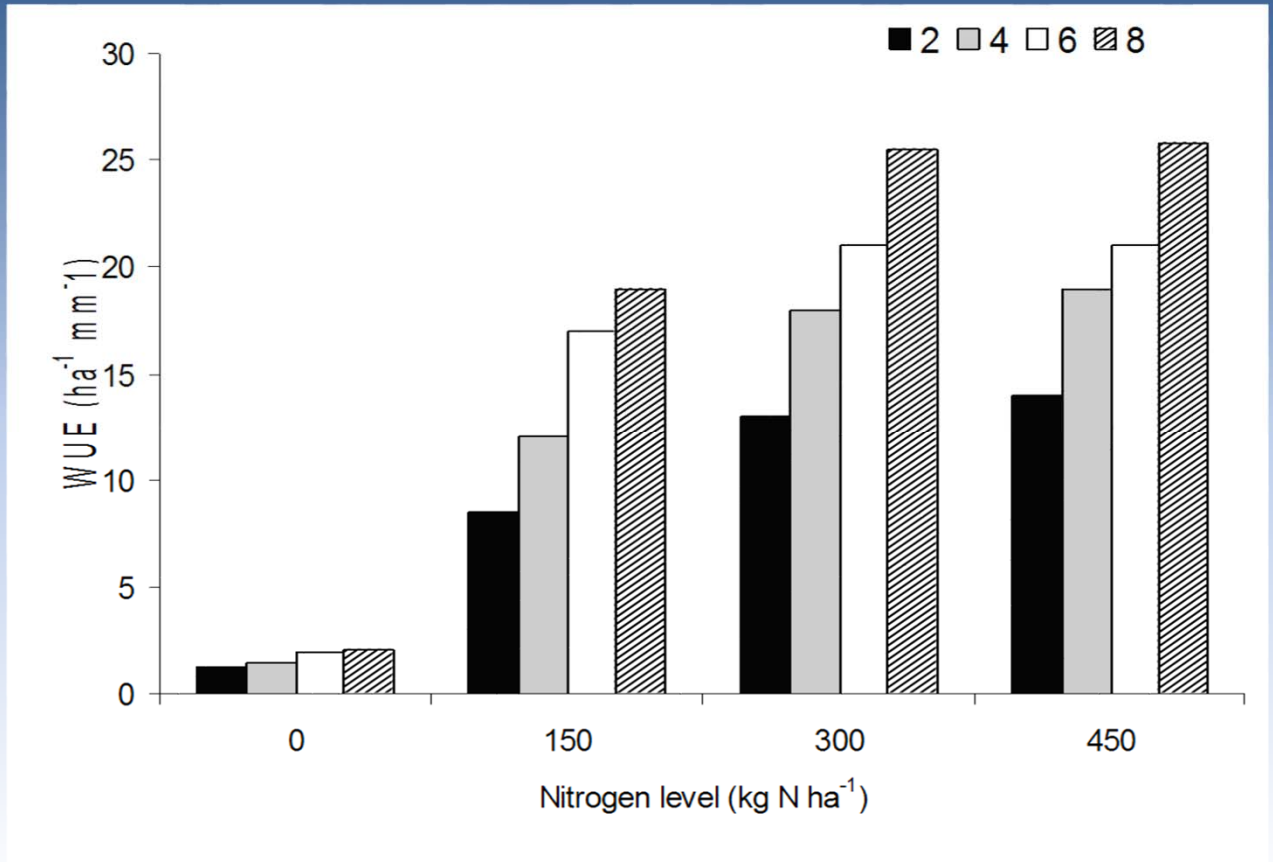
LAI = Leaf Area Index

Water use efficiency (WUE)

$$= \frac{\text{Dry matter yield (kg DM ha}^{-1}\text{)}}{ET_c \text{ (mm)}}$$

$$= \text{kg (DM / CP) ha}^{-1} \text{ mm}^{-1}$$

CROP WATER USE EFFICENCY



The effect of different levels of N (0, 150, 300 and 450 kg N ha^{-1}) and time of defoliation (2, 4, 6 and 8 weeks) on the WUE of Italian ryegrass
(modified from Theron & van Rensburg, 1998).

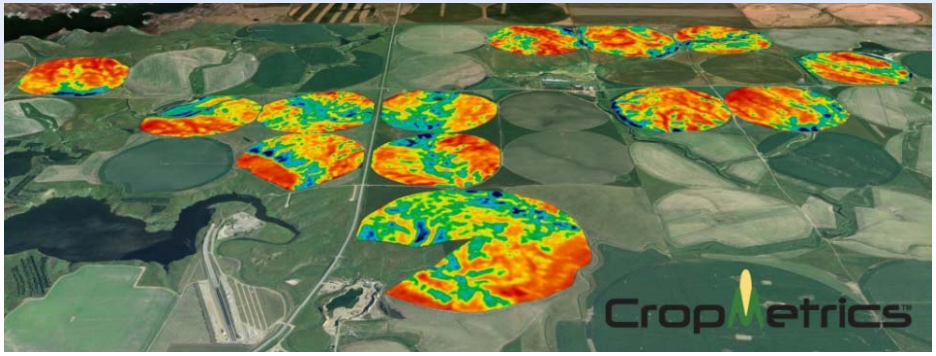
CROP WATER MANAGEMENT

ATMOSPHERIC EVAPORATIVE DEMAND responsible for higher water requirement

Average water use should not be used

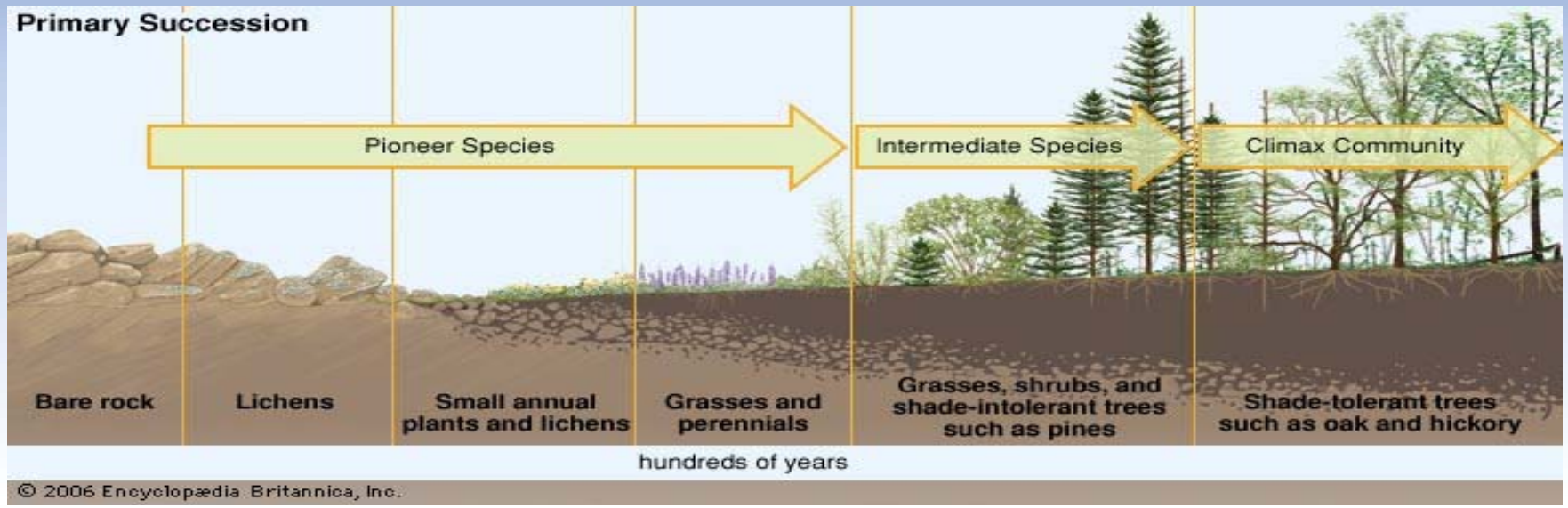
25 mm week^{-1}

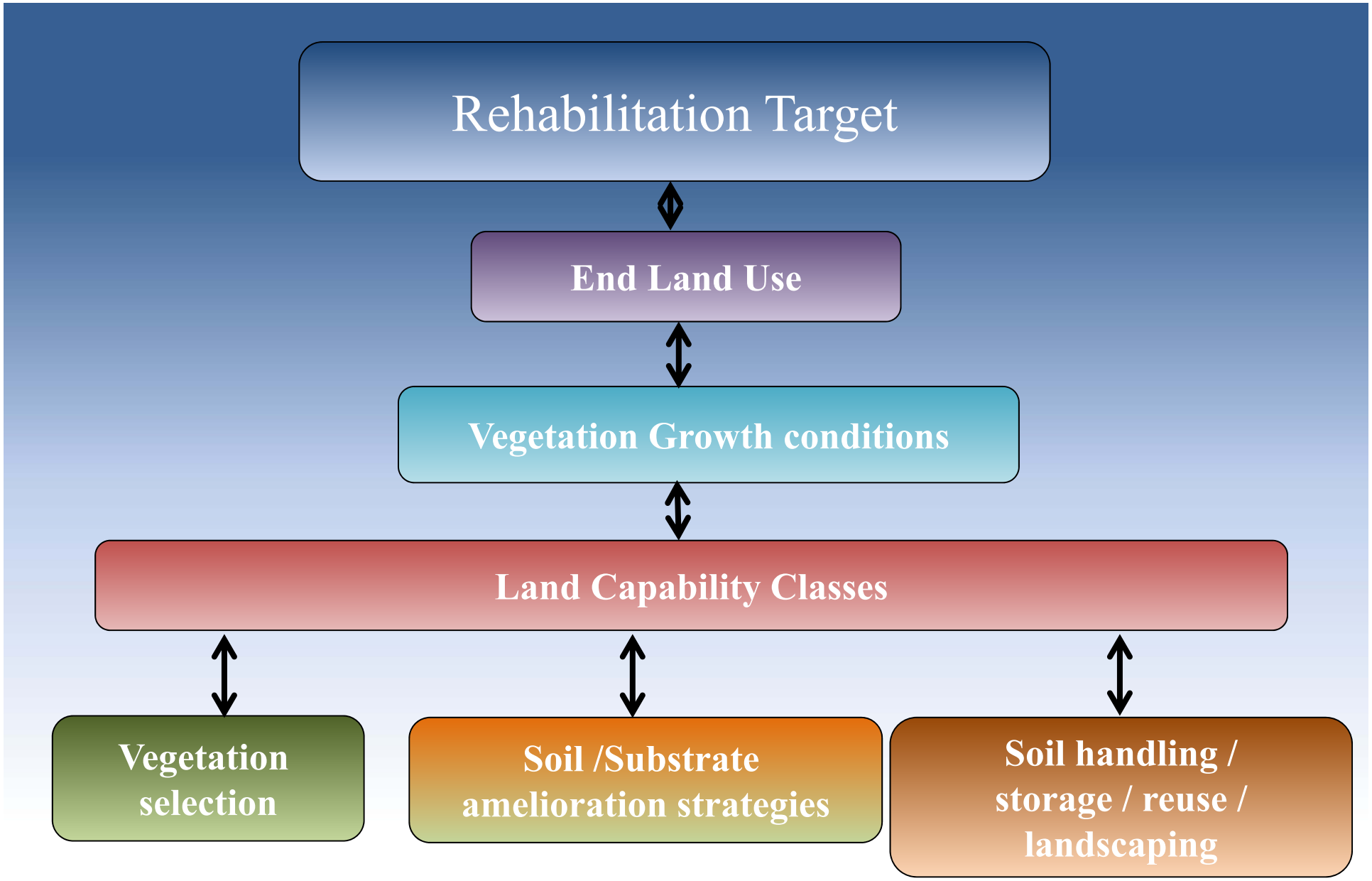
- Under / over irrigation
- Lower yields
- Nutrient loss (Leaching)
- Variable cutting cycles
- Higher costs ton^{-1} DM (certain times of year)

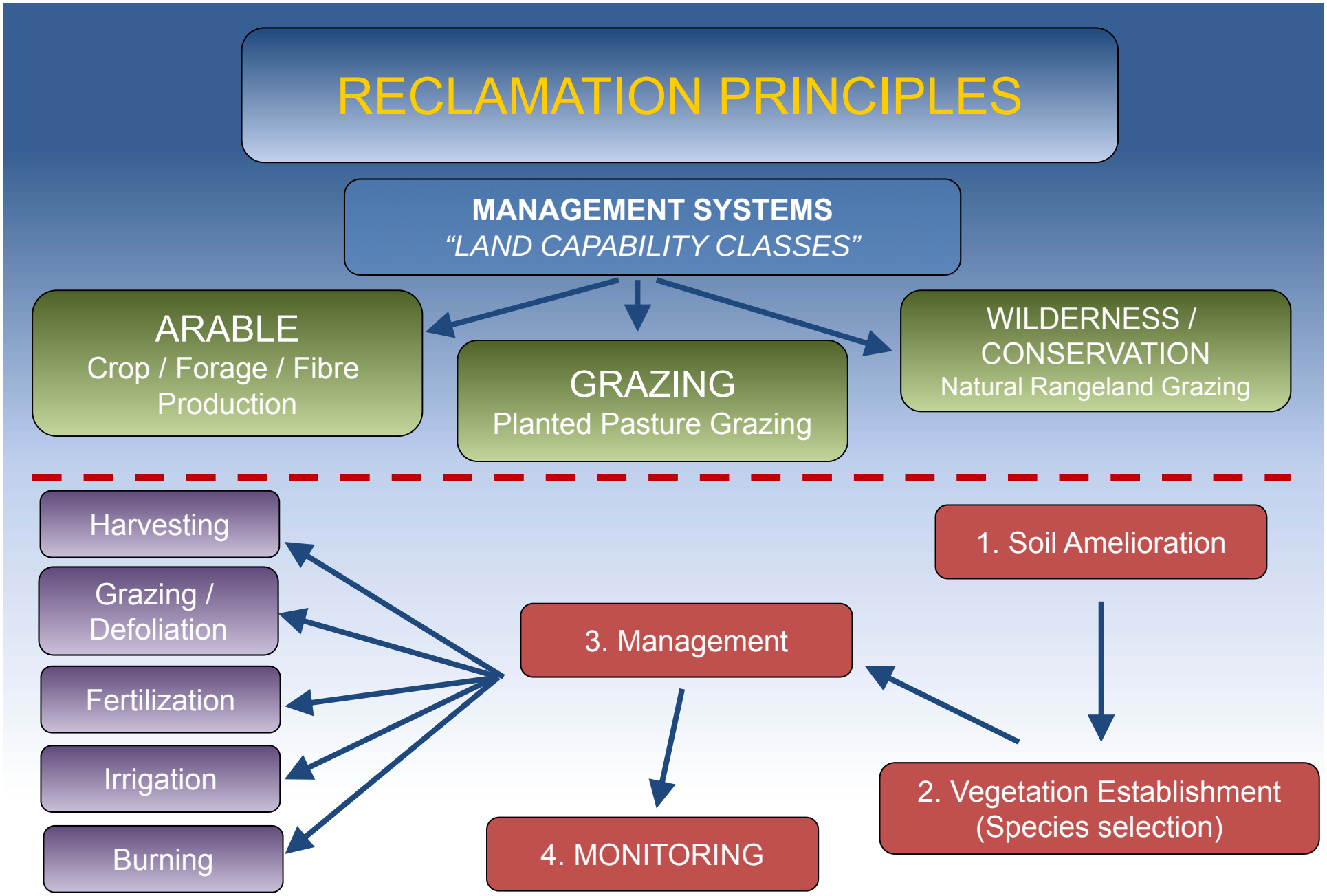


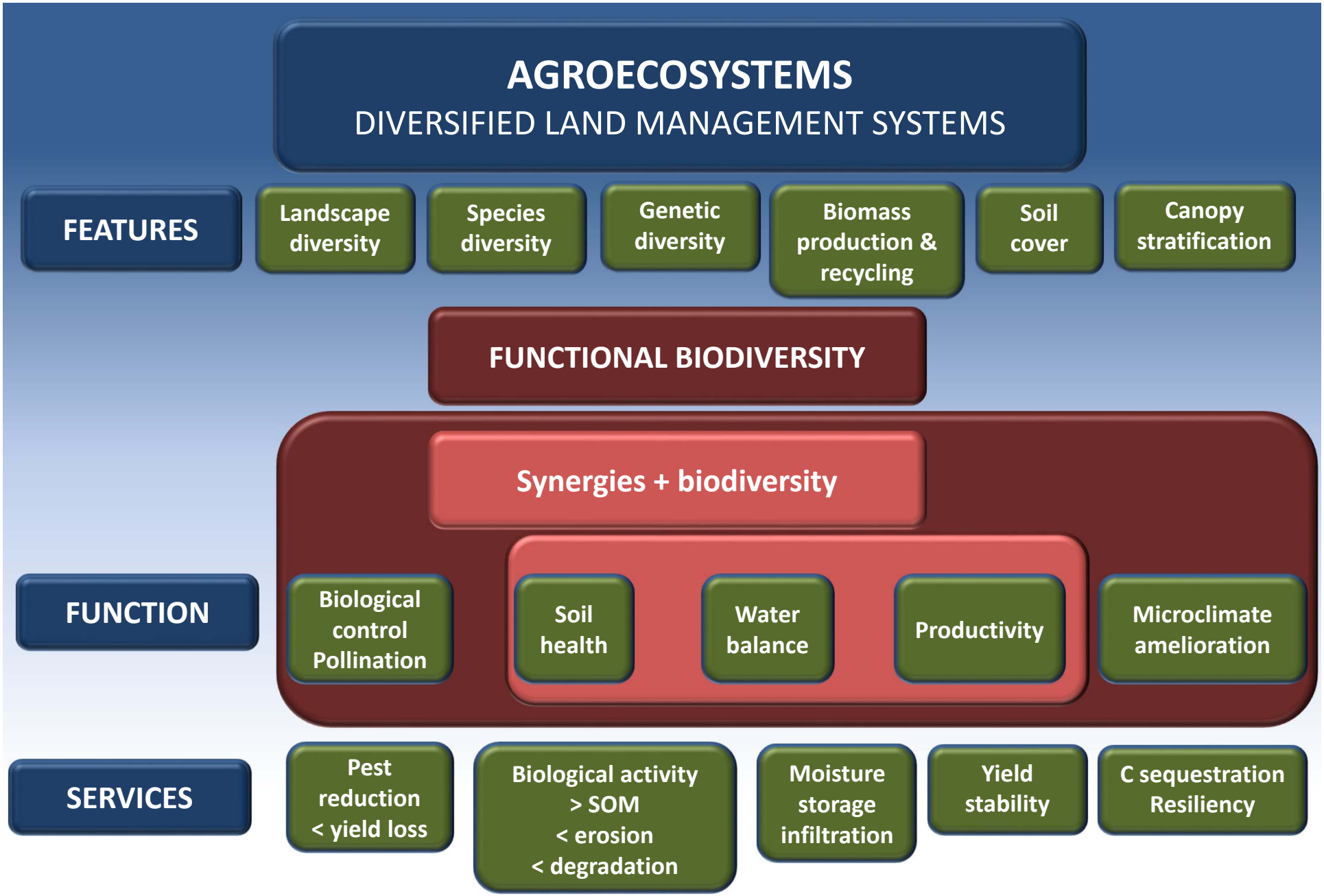
POST LAND RECLAMATION MANAGEMENT

New Agroecosystems









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