

SOIL AGGREGATES AND HUMUS SYSTEMS

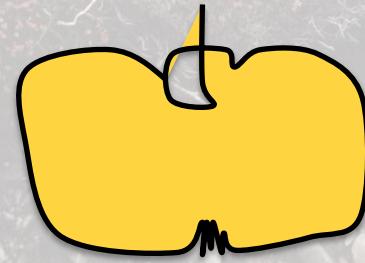
Augusto Zanella, Jean-François Ponge, Jérôme Juilleret, Nicolas Bernier, Stéphanie Topolianz, Manuel Blouin



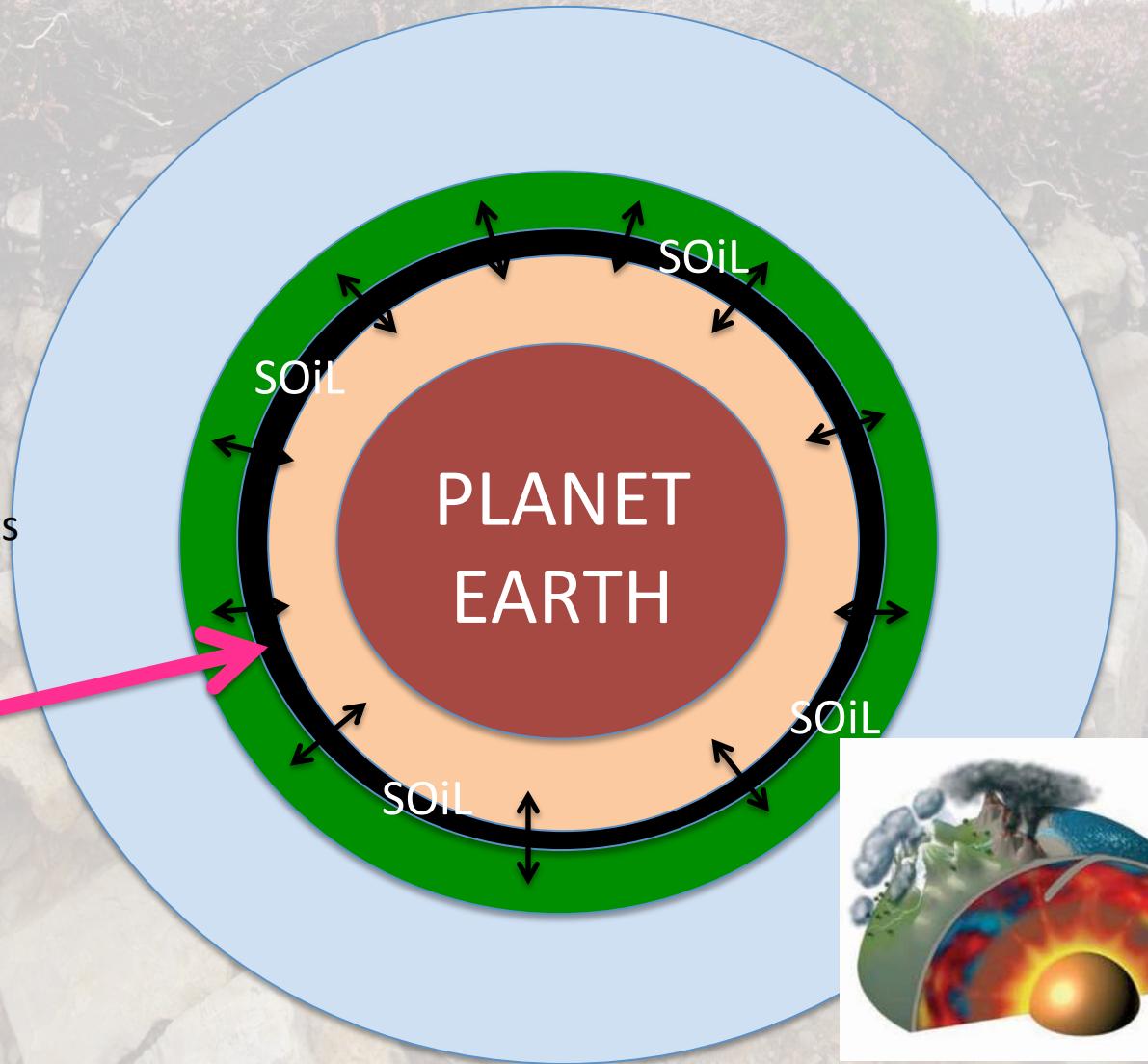
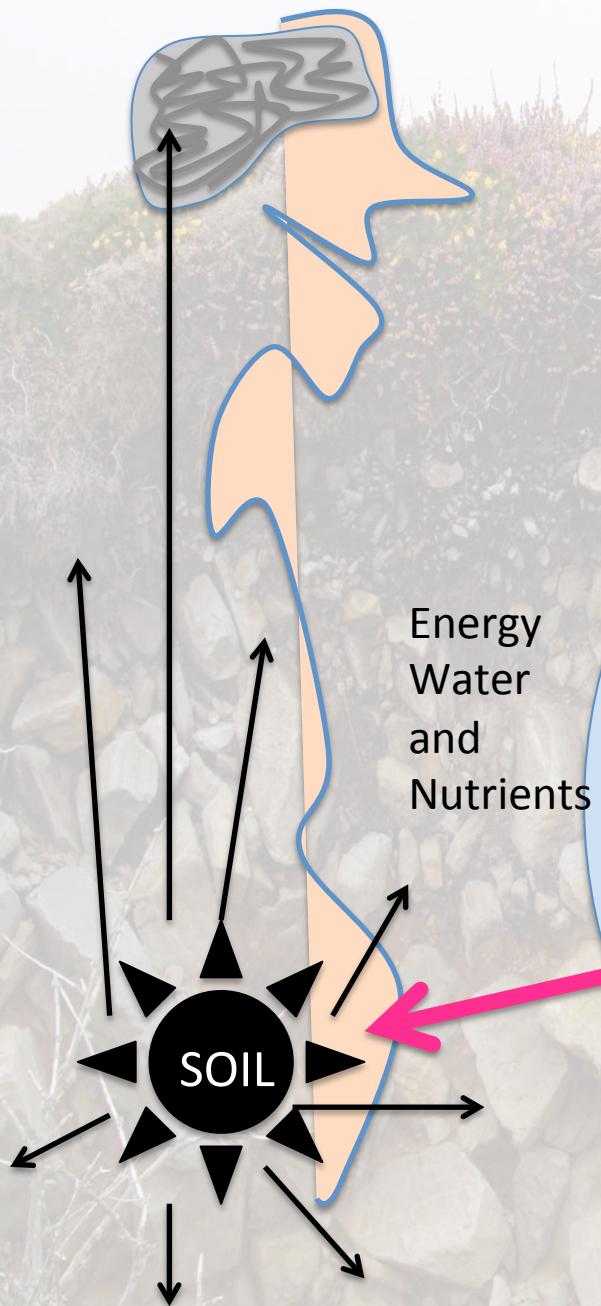
SOIL IS a great
DIGESTIVE system
in EVOLUTION

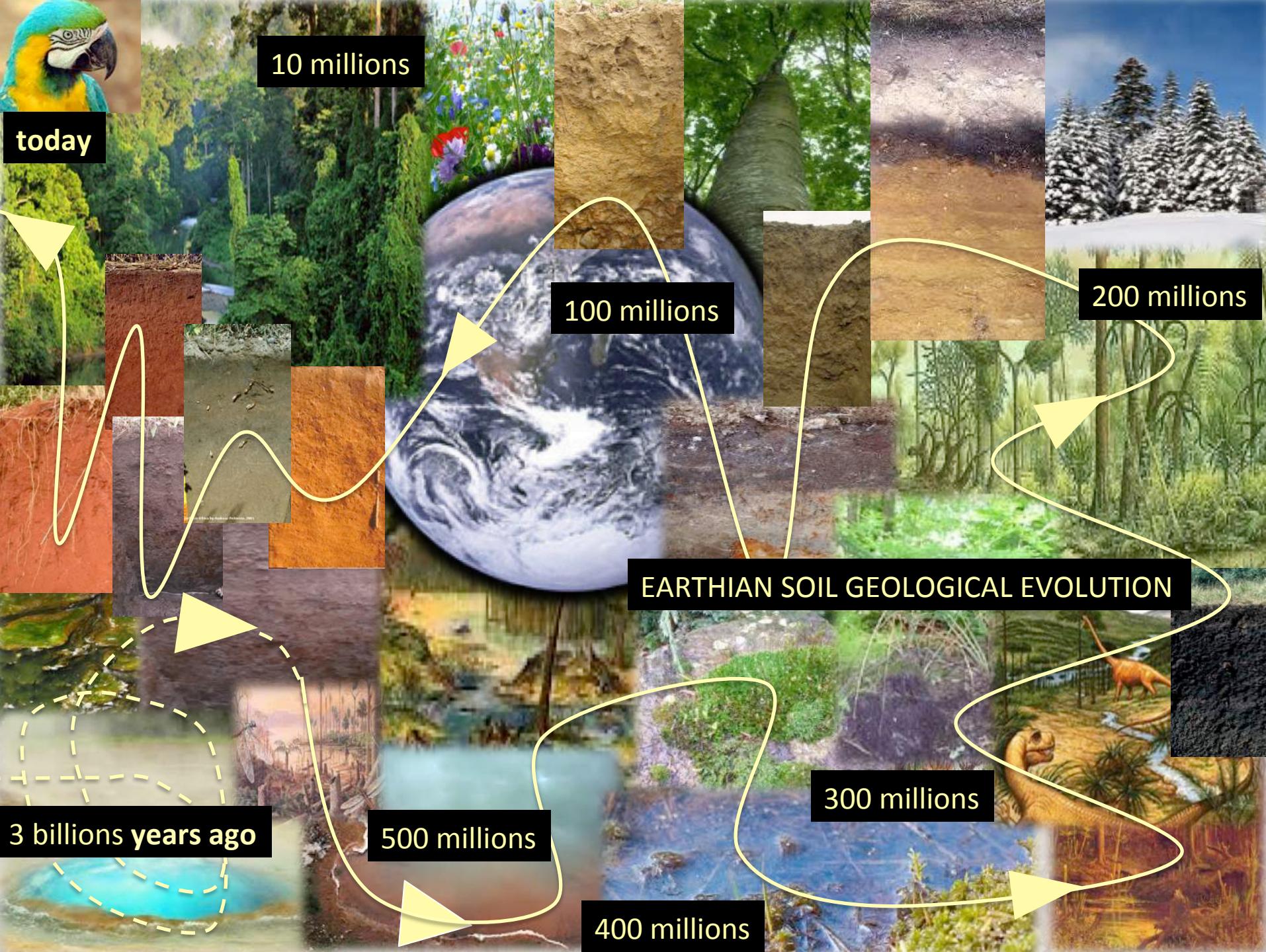
an ECOSYSTEM
structured in
AGGREGATES

AGGREGATES
are mandatory for
sustainable
AGRICULTURE

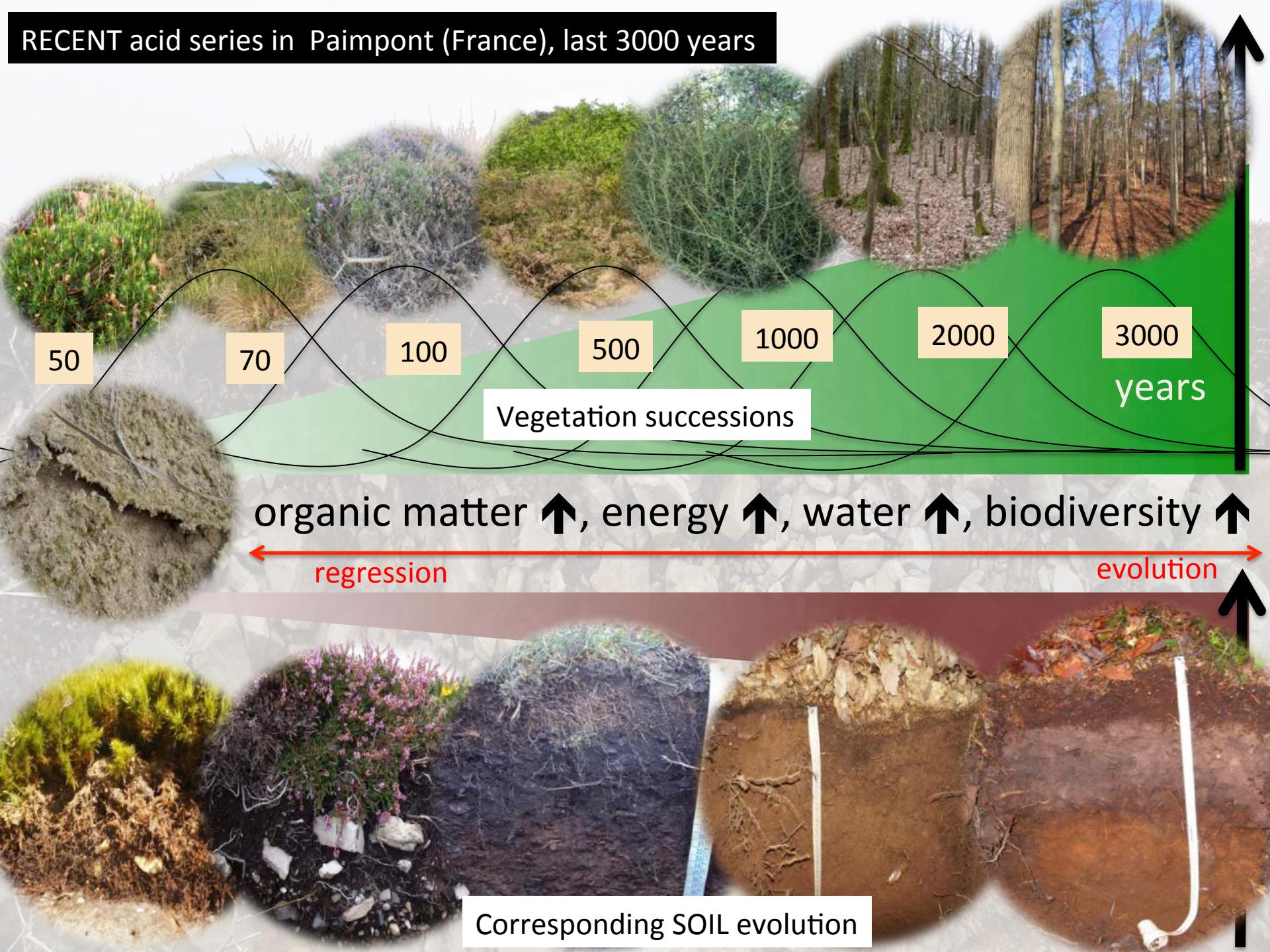


What's soil?



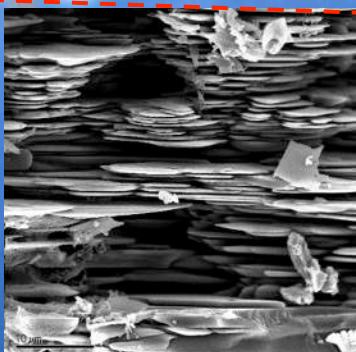
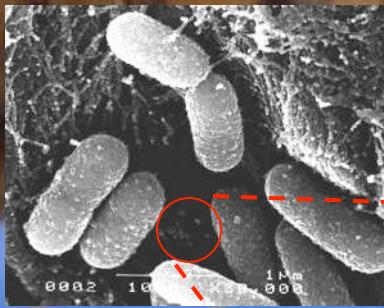


RECENT acid series in Paimpont (France), last 3000 years



Soil bacteria: 1 billion in a soil gram, corresponding to 1000-5000 species

The soil **structure** is
the fruit of the
living organisms-
mineral world
co-evolution



Fungi: measured more than 2000 km of hyphae (10 % actives) in 1 m² of soil and more than 100 species in a single beech forest



Poor in bases soils



digestive systems



Rich in bases soils





OL

Deciduous forest



Coniferous forest



Mediterranean forest



OF



OH



maA



miA



meA

TANGEL

European forest humus systems

MOR

AMPHI

MULL

MODER

Periodically DRY climate and
base-rich parent material

COLD climate and
base-poor parent material

TEMPERATE and NEUTRAL

Organic
RESTS

zoOF

zoOH

OH

Organic
RESTS

meA

ORGANO-MINERAL
AGGREGATES

nOL

maA

miA

OH

E

Organic
RESTS

nozOF

nozA

E

Mineral

CaCO_3

BioMESO

BioMACRO

BioMICRO

SiO_2

TANGEL

European forest humus systems

MOR

AMPHI

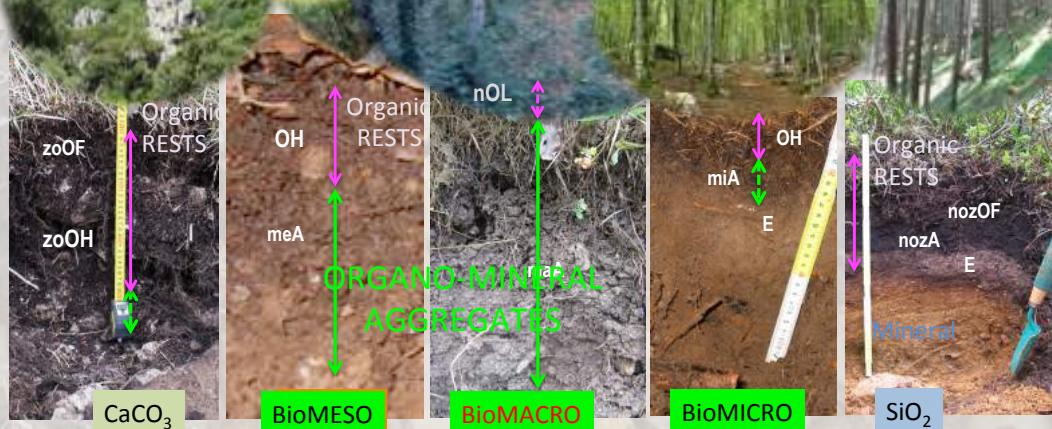
MULL

MODER

Periodically DRY climate and base-rich parent material

COLD climate and base-poor parent material

TEMPERATE and NEUTRAL



Few to many years

LITTER disappears
in less than 1 year

Few to many years



MACRO

Anecic earthworms

> 4-5 mm

Mostly from anecic (and large endogeic) earthworms
 organic-mineral, homogeneous pulp with mineral grains,
 cylindrical or more or less isodiametric, often “boweled”



A horizons

= < 3-4 mm

Mostly from small annelids: small endogeic and epigeic earthworms, large enchytraeids
 holorganic, finely homogeneous pulp,
 spherical grains or short cylinders with conic tip



A , OH

>1-3 mm

From millipedes:
 Asymmetrical pills with prismatic tip, holorganic, heterogenous,
 composed of recognizable plant remains in cluster

From insects (larval stages of flies):
 spherical grains lumped together in 2 or 3, holorganic,
 homogeneous, composed of unidentifiable organic fragments

MESO
 Endogeic earthworms,
 macroarthropods and large
 enchytraeids

4 mm

MICROMicroarthropods and small
enchytraeids

=< 1 mm

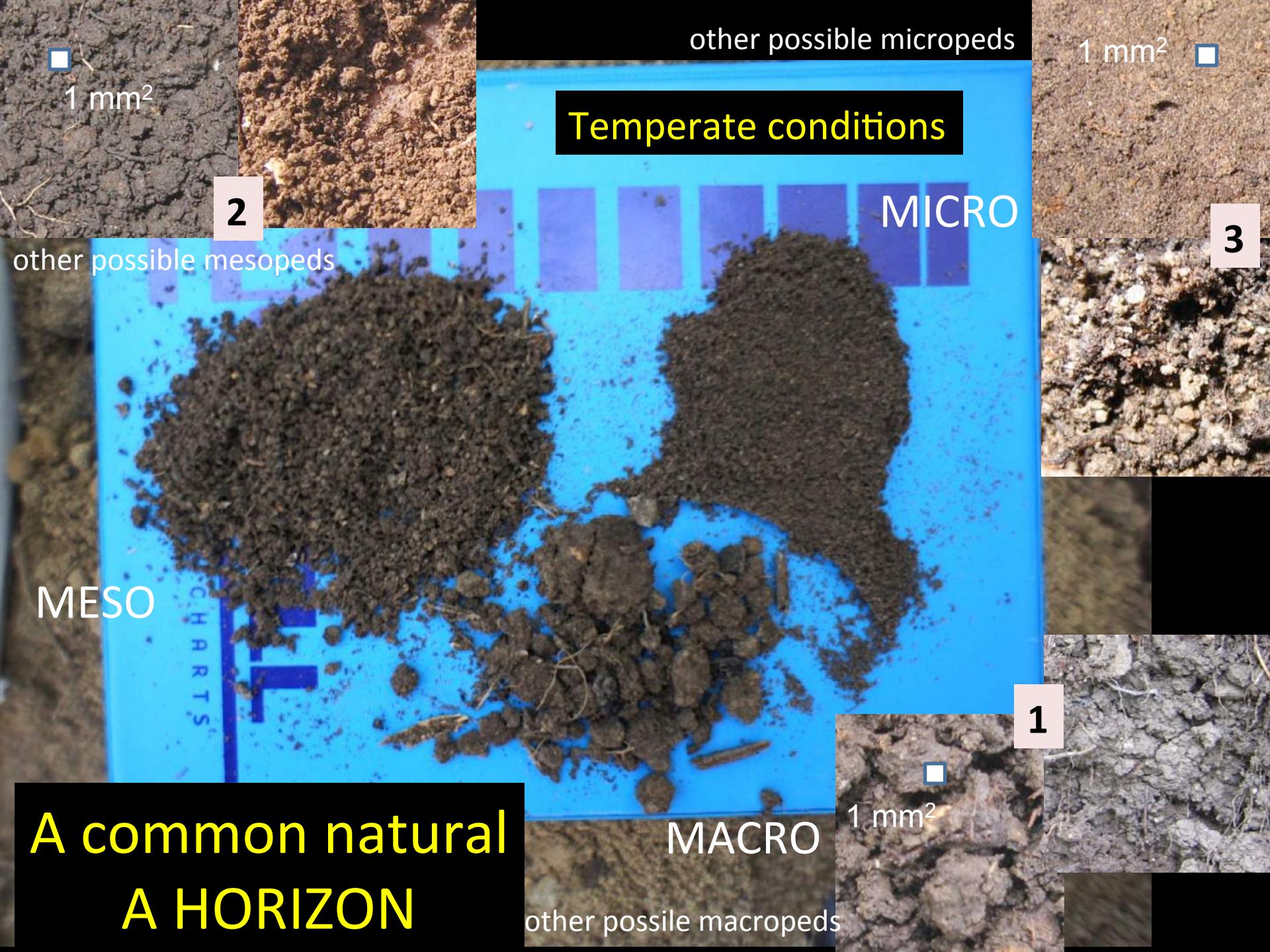
From small enchytraeids:
 holorganic and hemiorganic, in clusters,
 ovoid, fluffy in contour, often compacted when aged

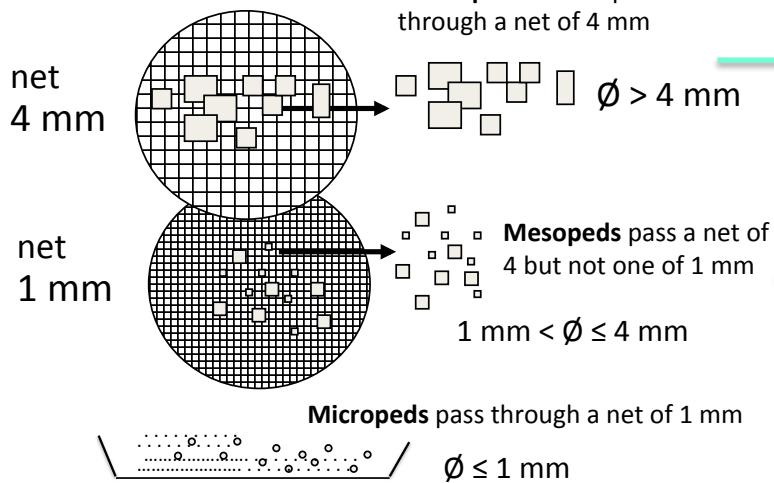
<< 1 mm

From springtails:
 holorganic and hemorganic, not in clusters,
 cylindrical, regular bound

From mites:
 holorganic, spherical, often in clusters, very regular
 bound

1 mm





ORGANIC-MINERAL structures

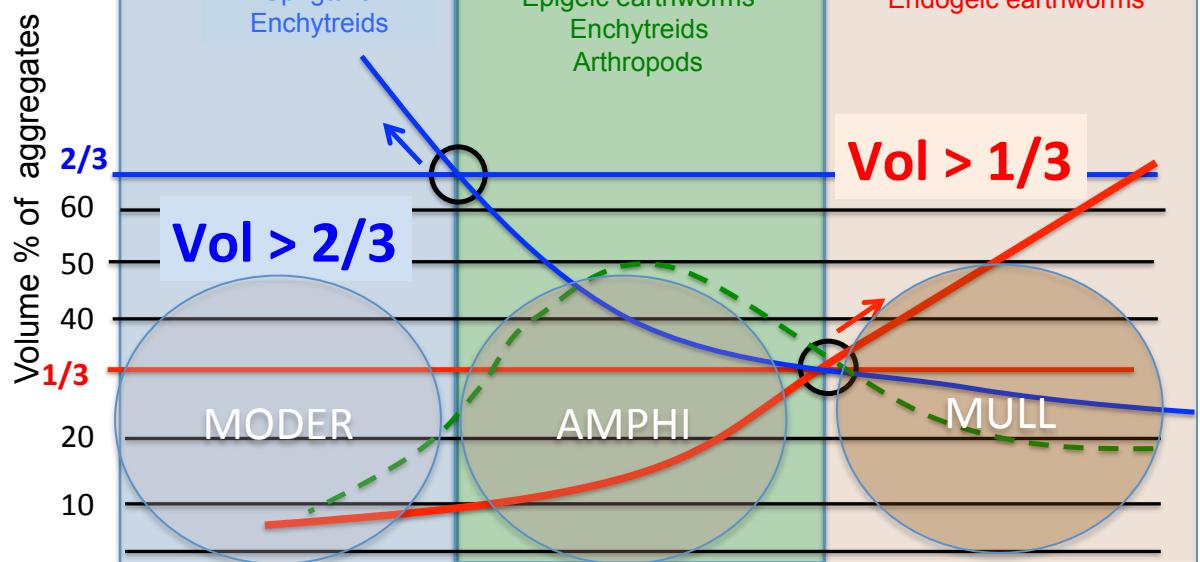
Horizon	miA	meA	maA
Aggregates size (droppings)	$\phi \leq 1 \text{ mm}$	$1 \text{ mm} < \phi \leq 4 \text{ mm}$	$\phi > 4 \text{ mm}$
Animals size Dominant animals	Small-size fauna ($L \leq 5 \text{ mm}$) Mites Springtails Enchytreids	Mean-size fauna ($5 \text{ mm} < L \leq 50 \text{ mm}$) Endogeic and Epigeic earthworms Enchytreids Arthropods	Large-size fauna ($L > 50 \text{ mm}$) Anecic earthworms Endogeic earthworms

ORGANIC structures

MOR

Harsh conditions

TANGEL

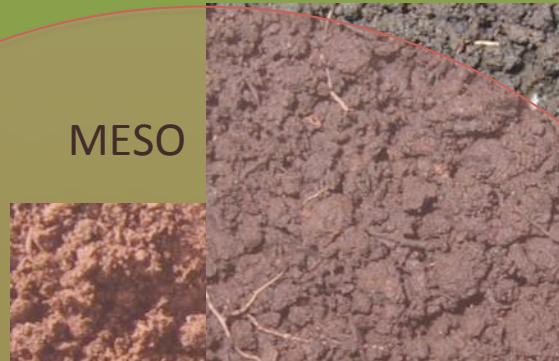


ZOOGENIC NATURAL STRUCTURES

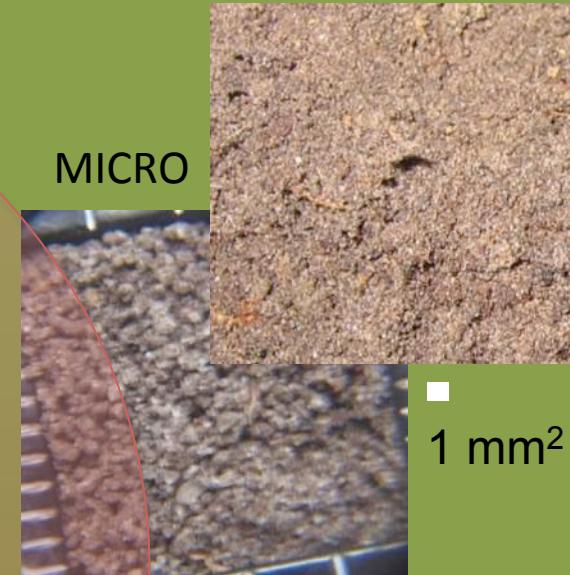
MACRO



MESO



MICRO



AGRO

MASSIVE



1 cm^2

NON
ZOOGENIC

1 cm^2

SINGLE GRAINED



1 mm^2

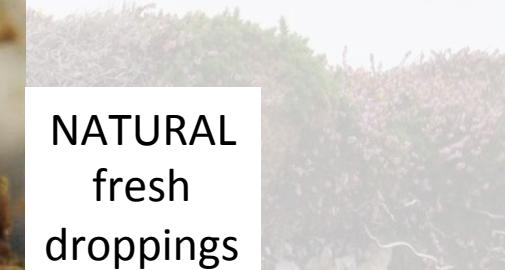


An old earthworm dropping
in a POORLY ZOOGENIC soil

**GRANULAR, FINE GRANULAR =
BIOMACROSTRUCTURED MATERIALS**



anecic



NATURAL
fresh
droppings

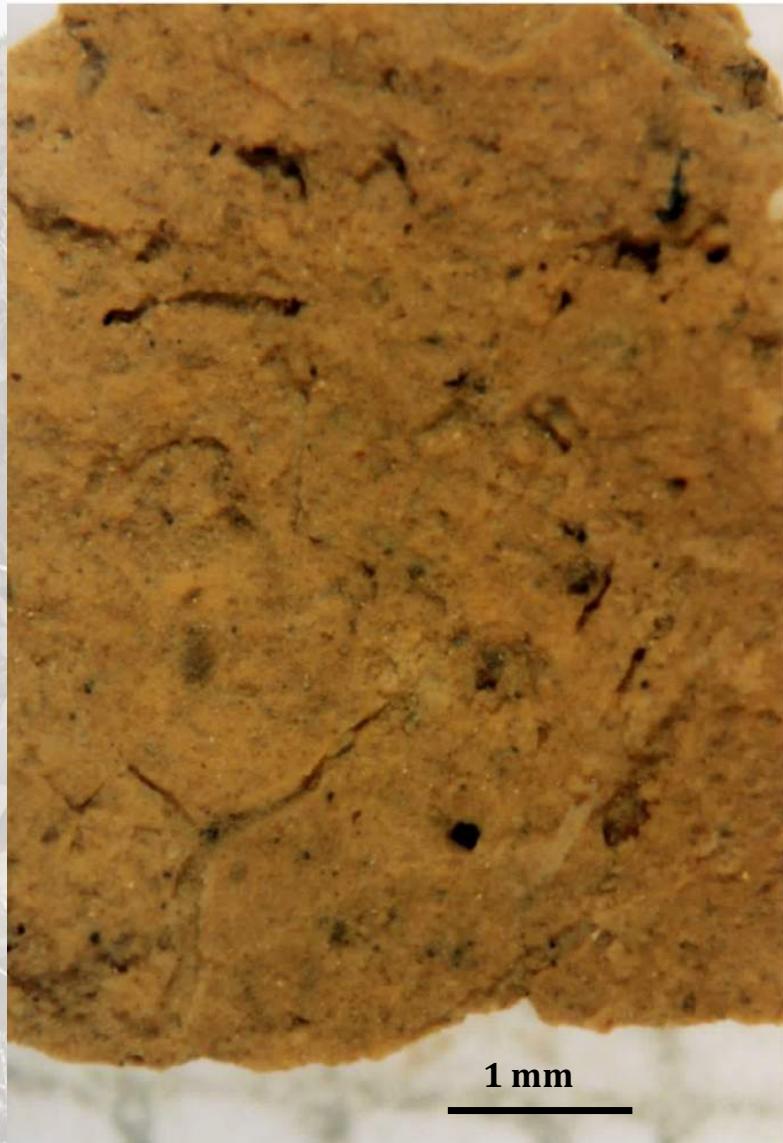


endogeic

VERY FINE GRANULAR, BIOMESOSTRUCTURED AND BIOMICROSTRUCTURED MATERIALS



Soil under anthropic pressure: porosity is limited to some poorly developed root channels

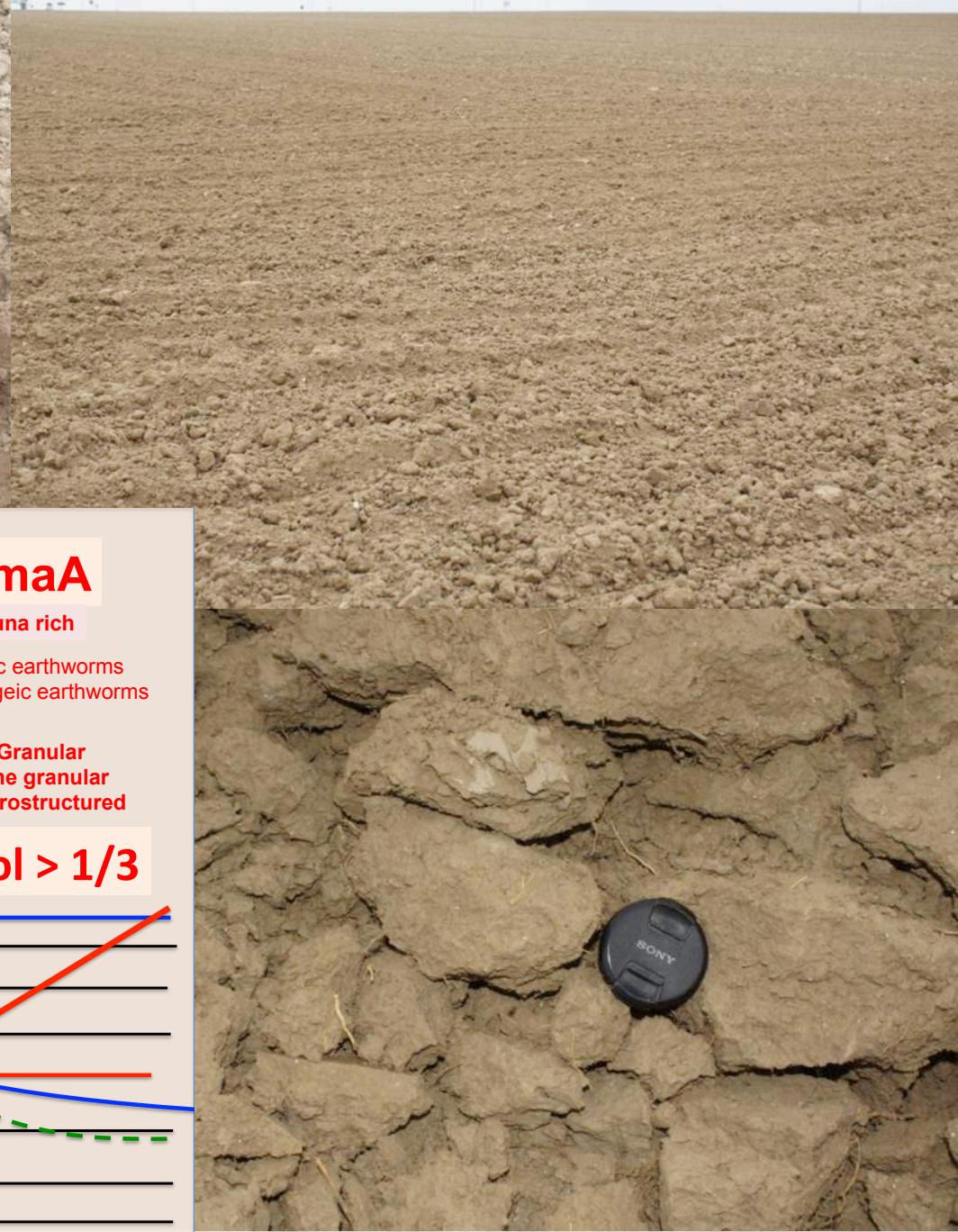
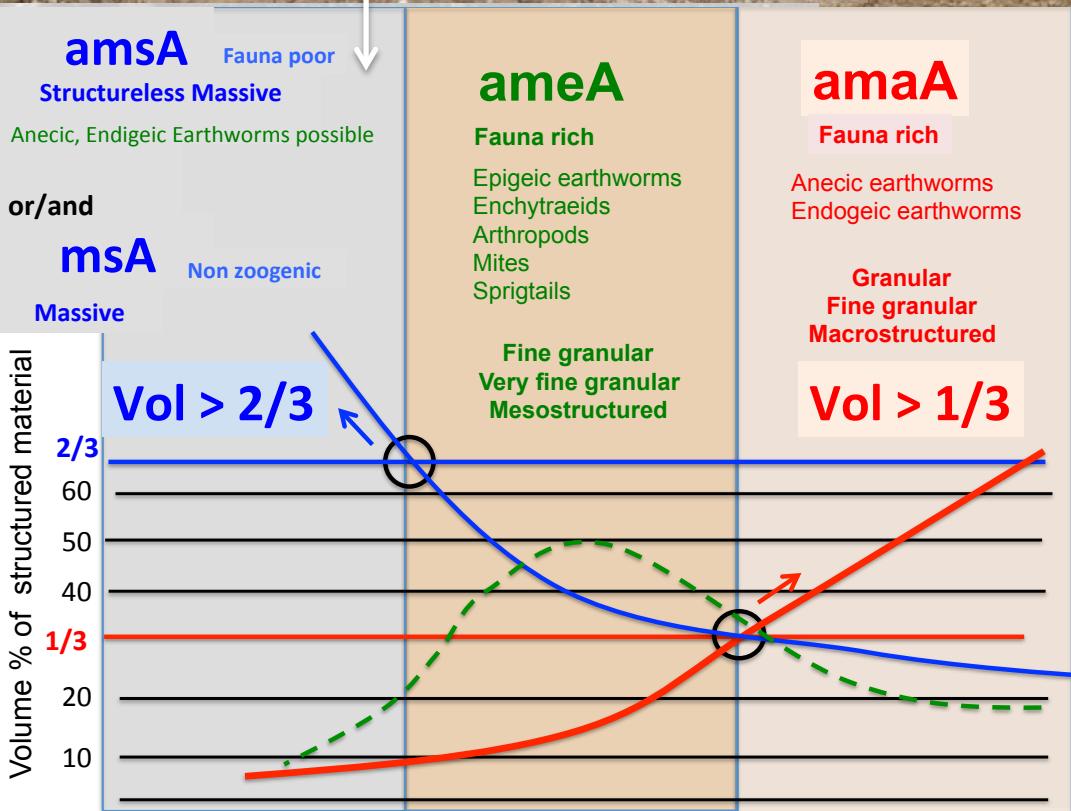


**NON ZOOGENIC
STRUCTURELESS
MASSIVE MATERIAL**



*compact
superficial
"crust"*

MASSIVE Agromull





MESO and MACRO Agromull

ameA

Fauna rich

Epigaeic earthworms
Enchytraeids
Arthropods
Mites
Springtails

Fine granular
Very fine granular
Mesostructured

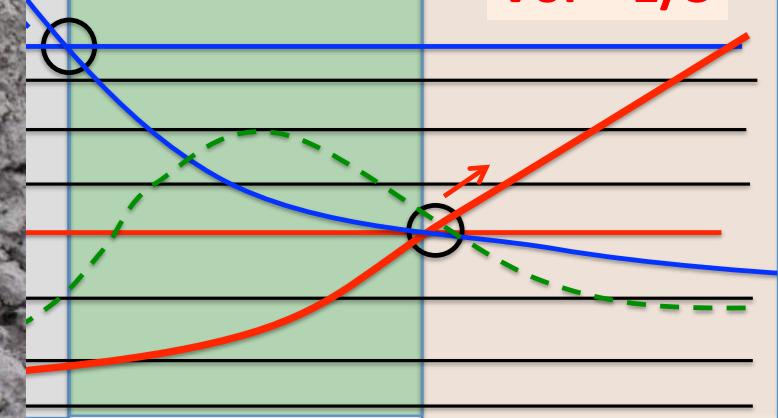
amaA

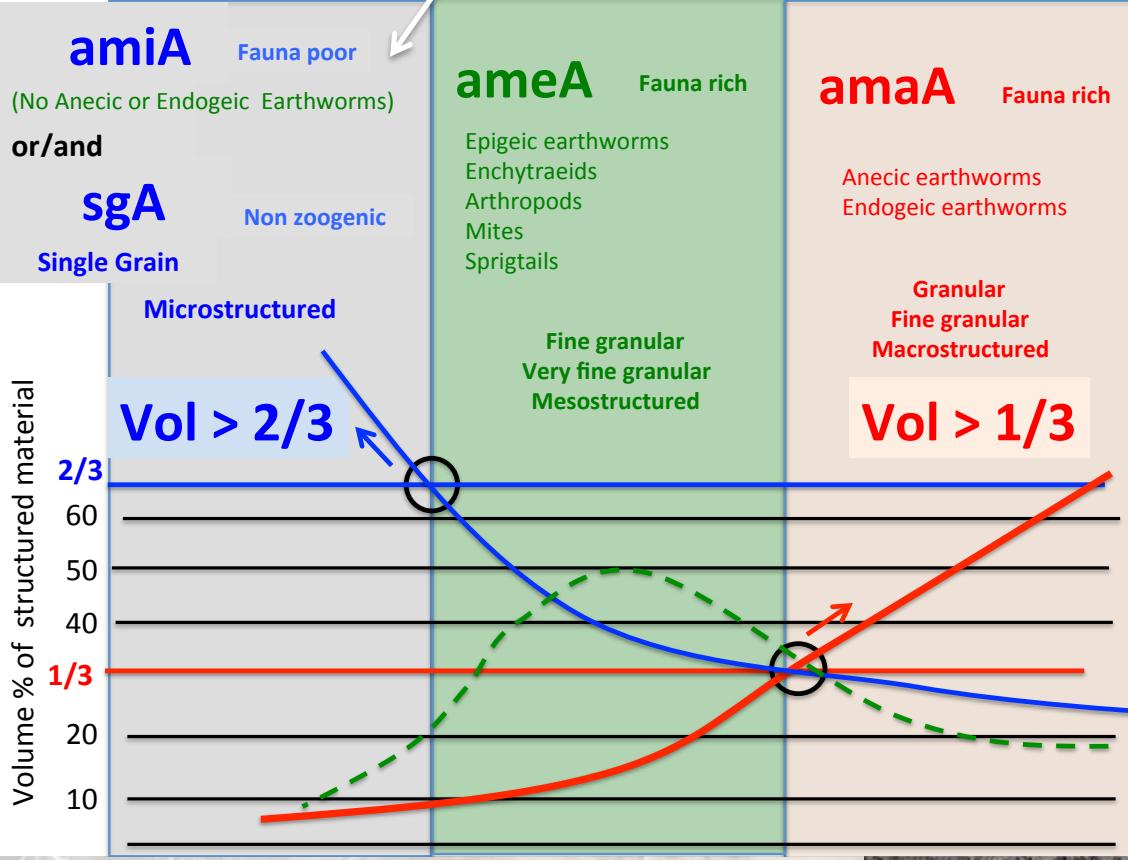
Fauna rich

Anecic earthworms
Endogeic earthworms

Granular
Fine granular
Macrostructured

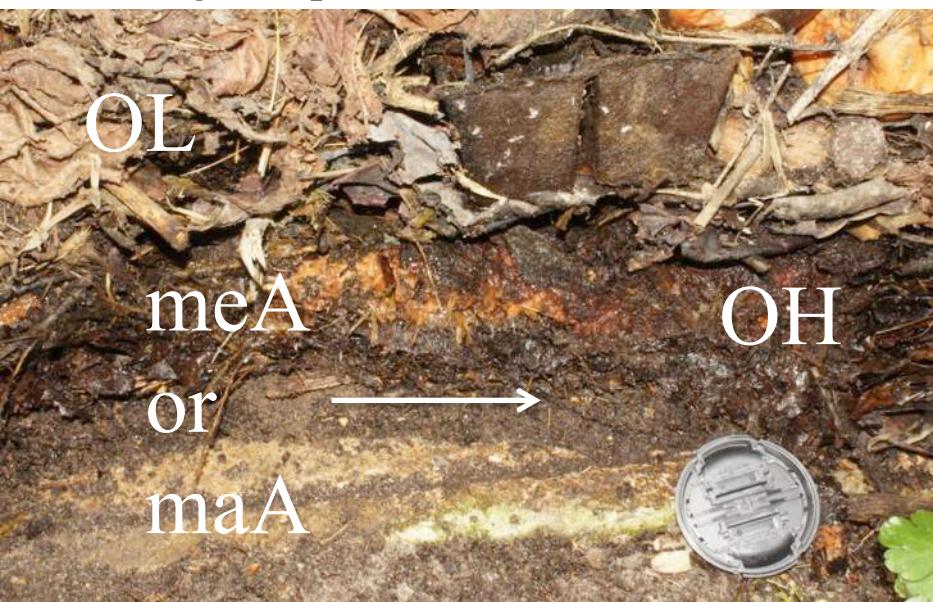
Vol > 1/3







Macro Agroamphi



ANTHROPOGENIC HUMUS HORIZONS

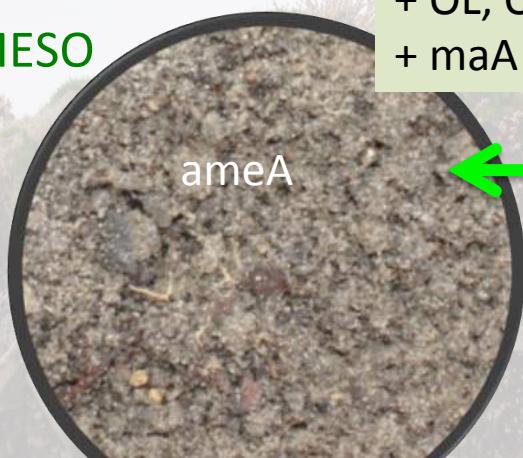


Restoring ANTHROPOGENIC structures

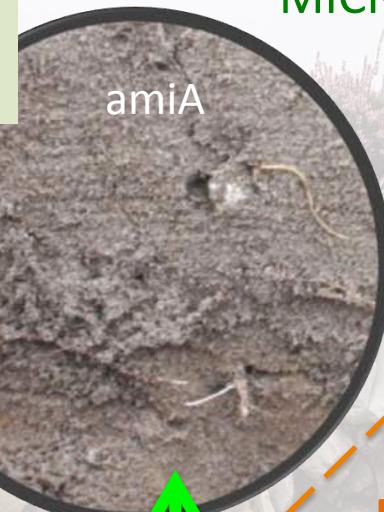
NON ZOOGENIC

ZOOGENIC

MESO



MICRO



Anthropogenic or natural



POORLY
ZOOGENIC

SINGLE GRAINED

+ OL, OF
+maA horizon



amsA

+ OL, OF
+ maA horizon

Anthropogenic
MASSIVE

+ OL, OF, OH
+ maA horizon



MASSIVE



Restoring soil
Restoring humanity
Romanie examples

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Thank you for your attention !!!

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