Soil and soil development

J. Frouz,
and many others

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esf evropský sociální fond v ČR
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

There are many def
features are:

- soil is upper part of
- soil is three phase s
and gas phase
- solid phase consist
- soil formation is pr
climatic conditions a
- most of decomposi
place in soil
- soil support belowg
water and nutrients a

"... and we can save 700 lira by not taking soil tests."

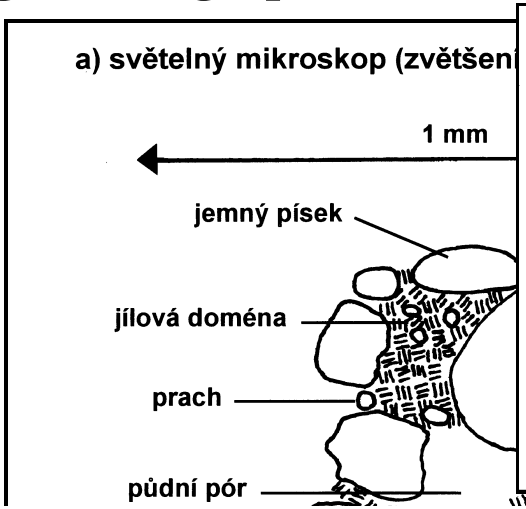
Soil is often unde

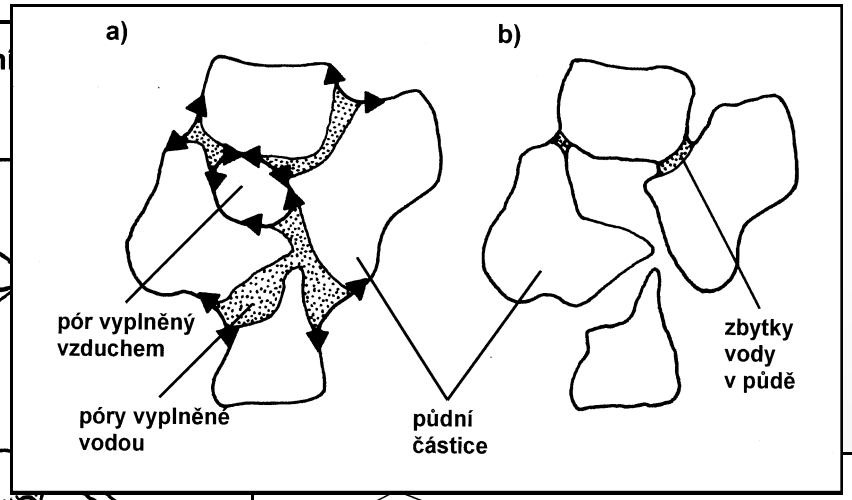
Soil is a large storage pool of water

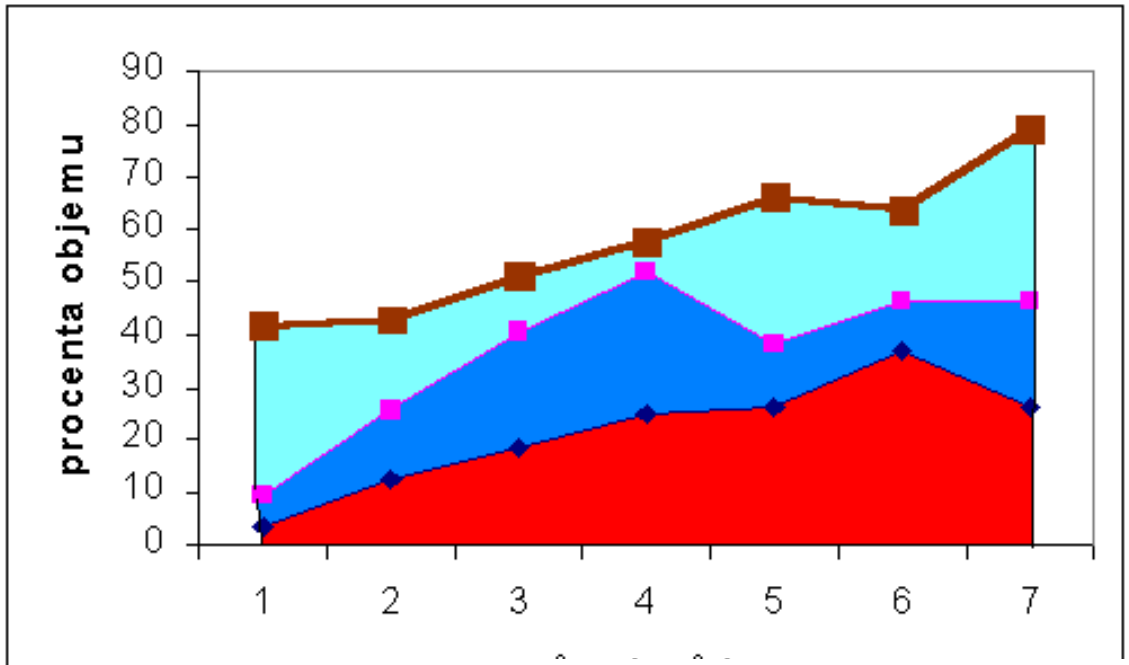
Mineral soil

Particles of different size

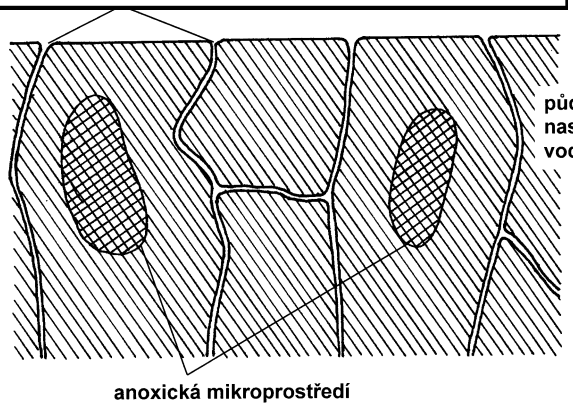
sand (>0,02mm)





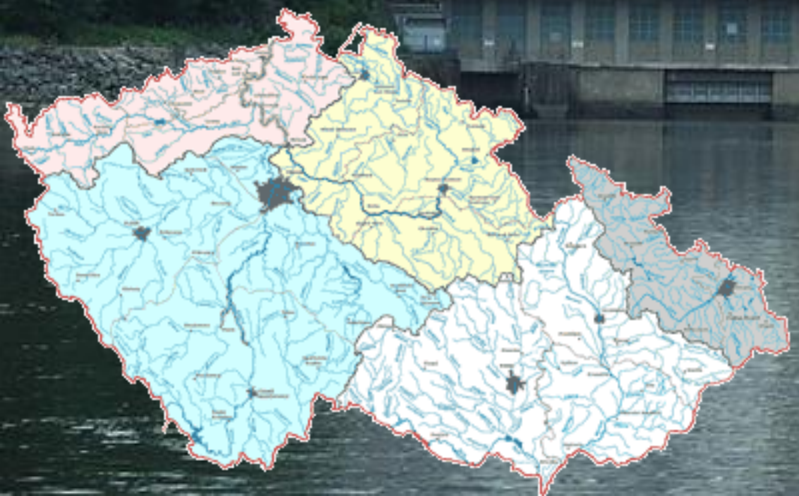


WP WFC porosity

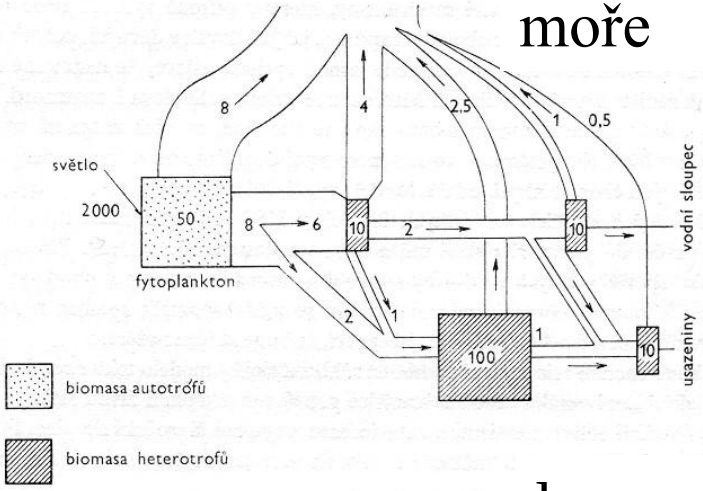


	presssure (kPa)	Pores diameter
Water saturation	0.1	3mm
WFC	10-33	3-4µm
WP	1500	0.2µm
Dry soil	10^5	-

6 dams on Vltava river c. **820** mil m^3 (maximal volume)
Soil water in watershed c. **3370** mil m^3 steady state **6740** mil m^3 max.



moře



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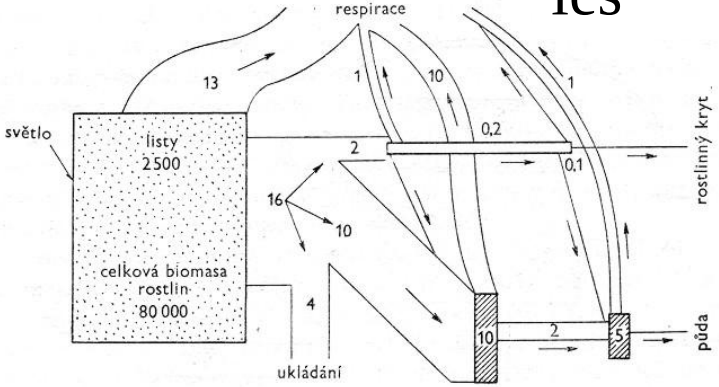
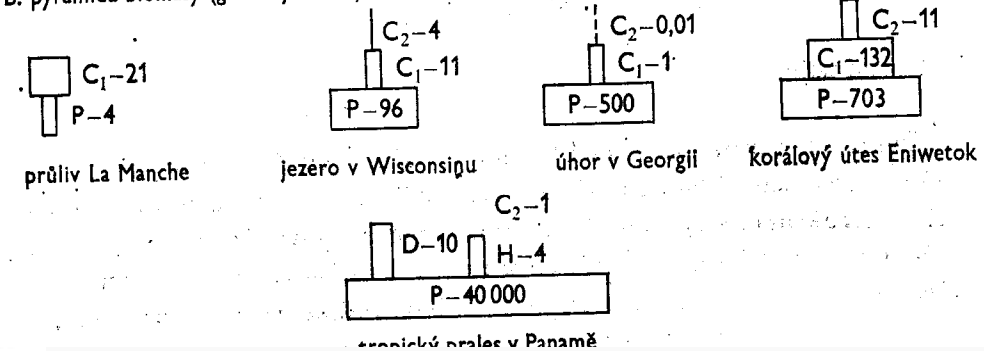
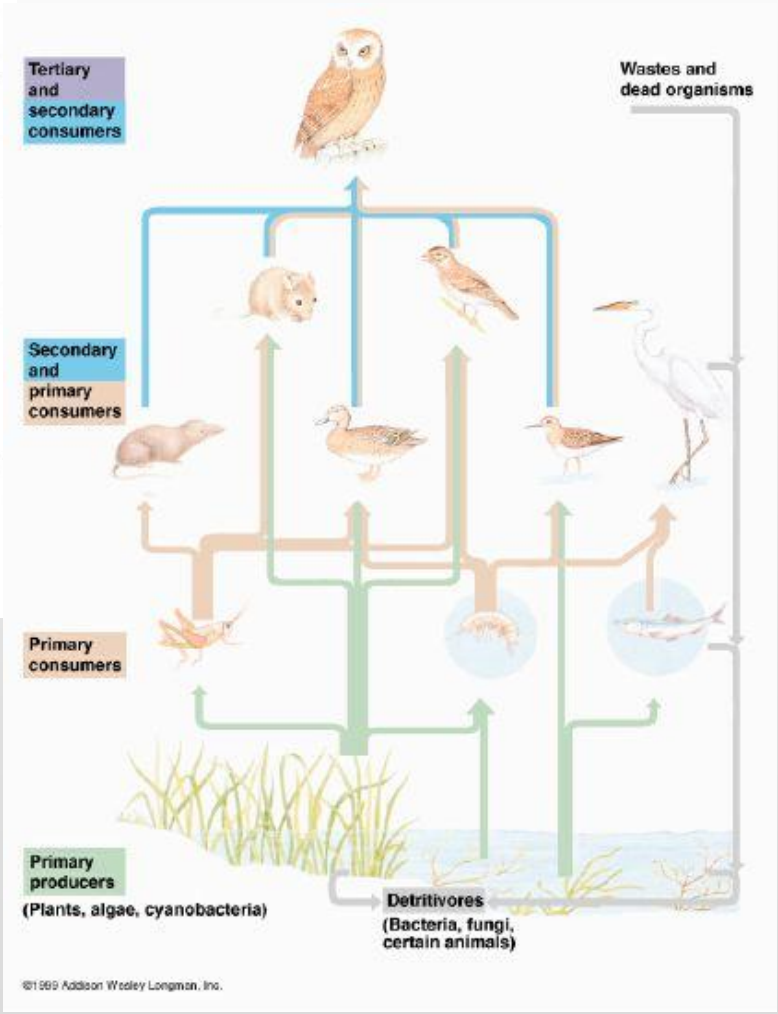
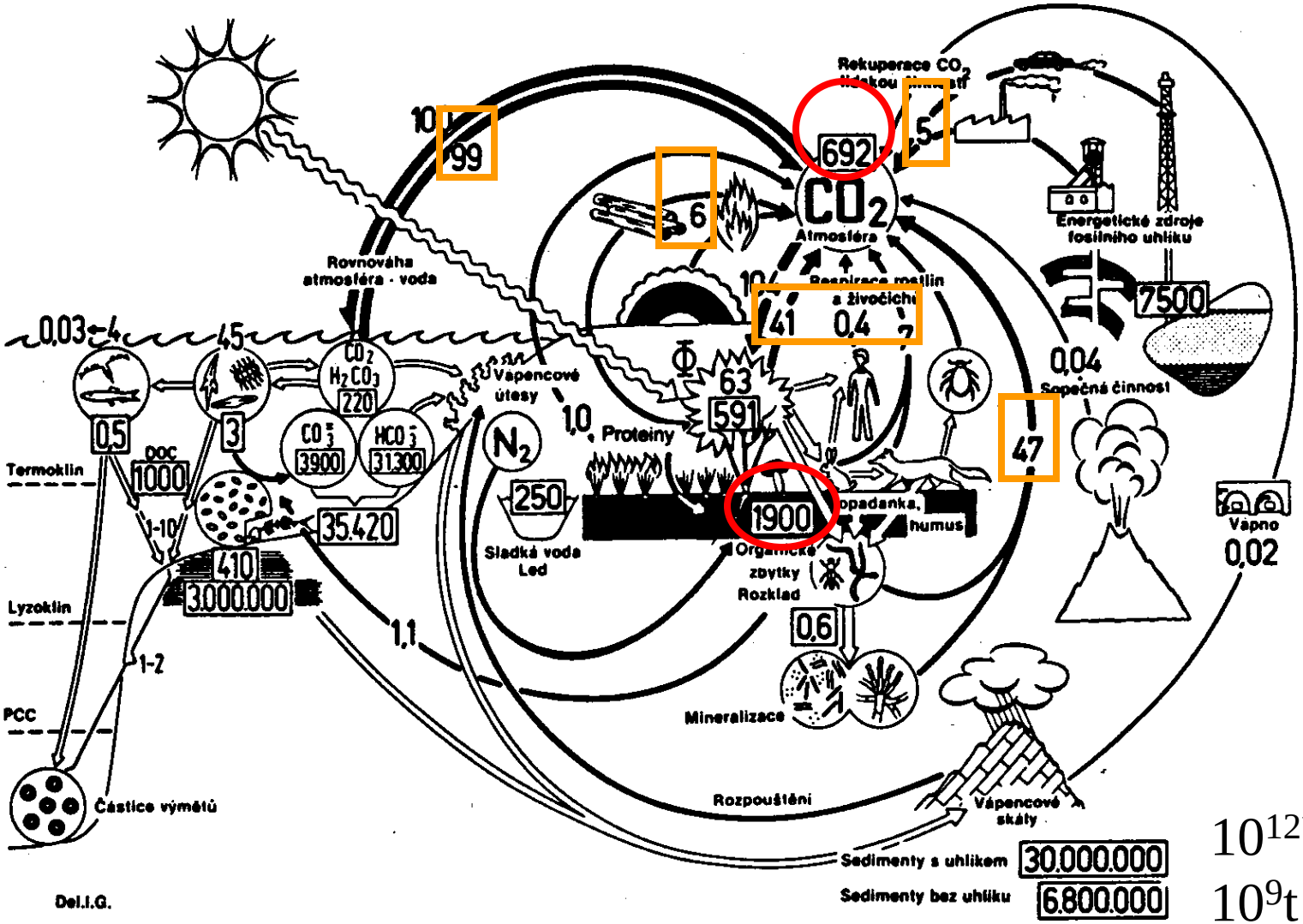


B. pyramida biomasy (g sušiny na m^2)



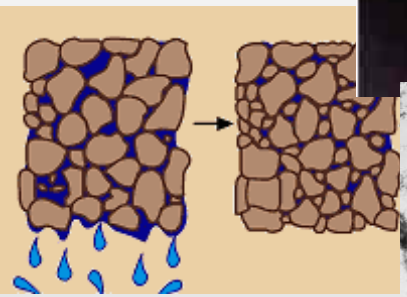


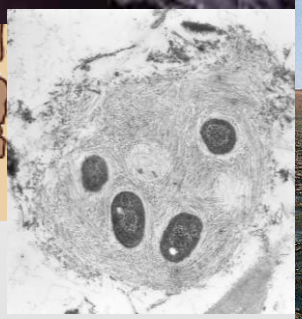


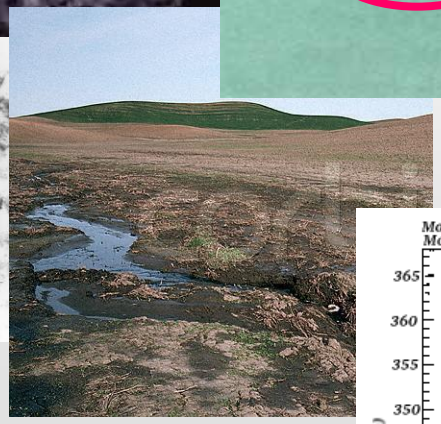
10^{12}kg

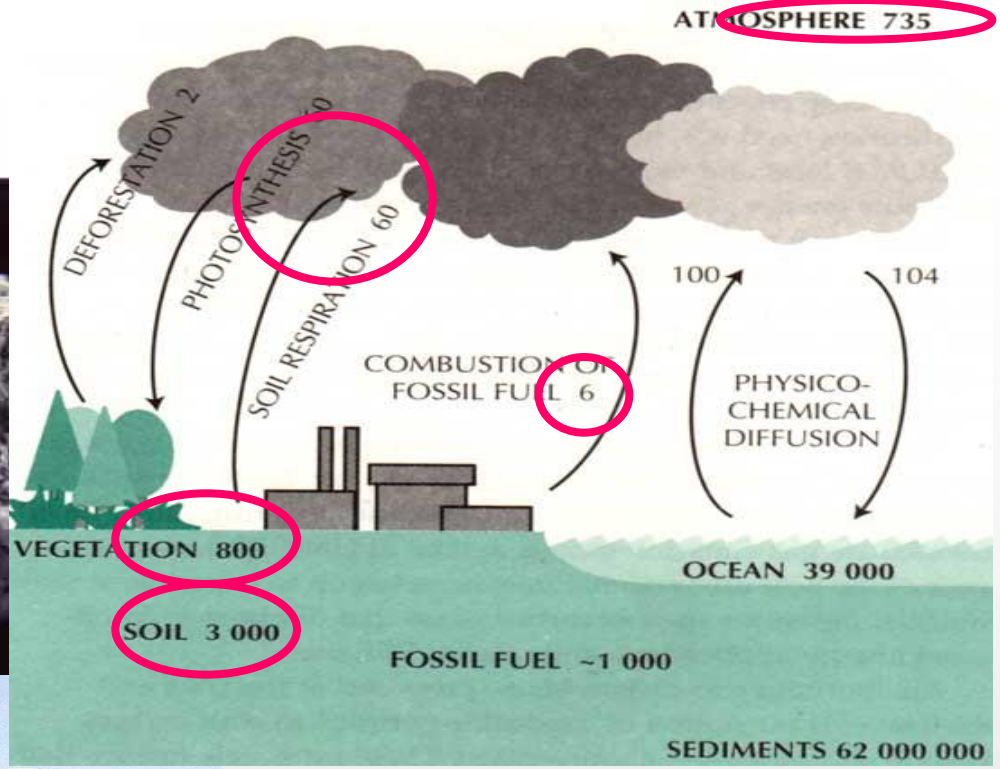
10^{9}t Tt

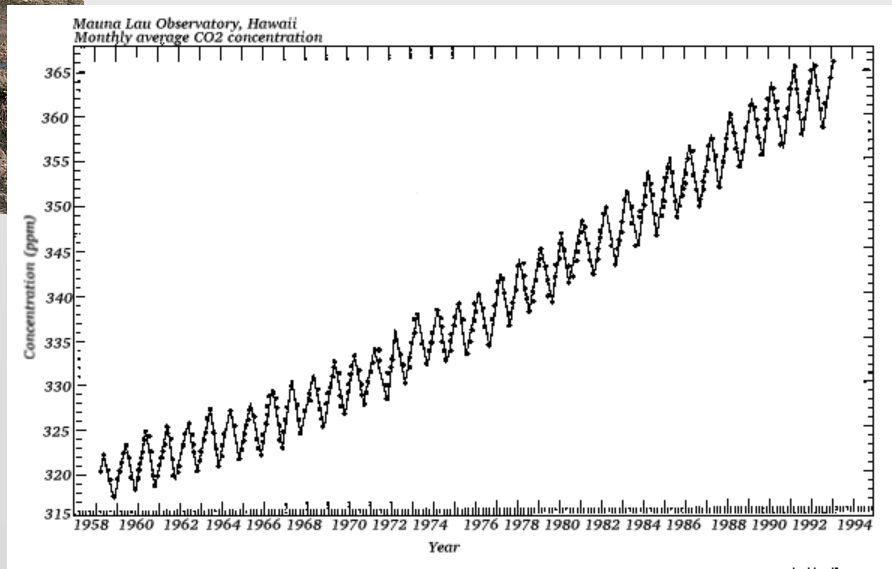
Why soil carbon ?











Diversity of soil biota

Belowgroud diversity larger than aboveground

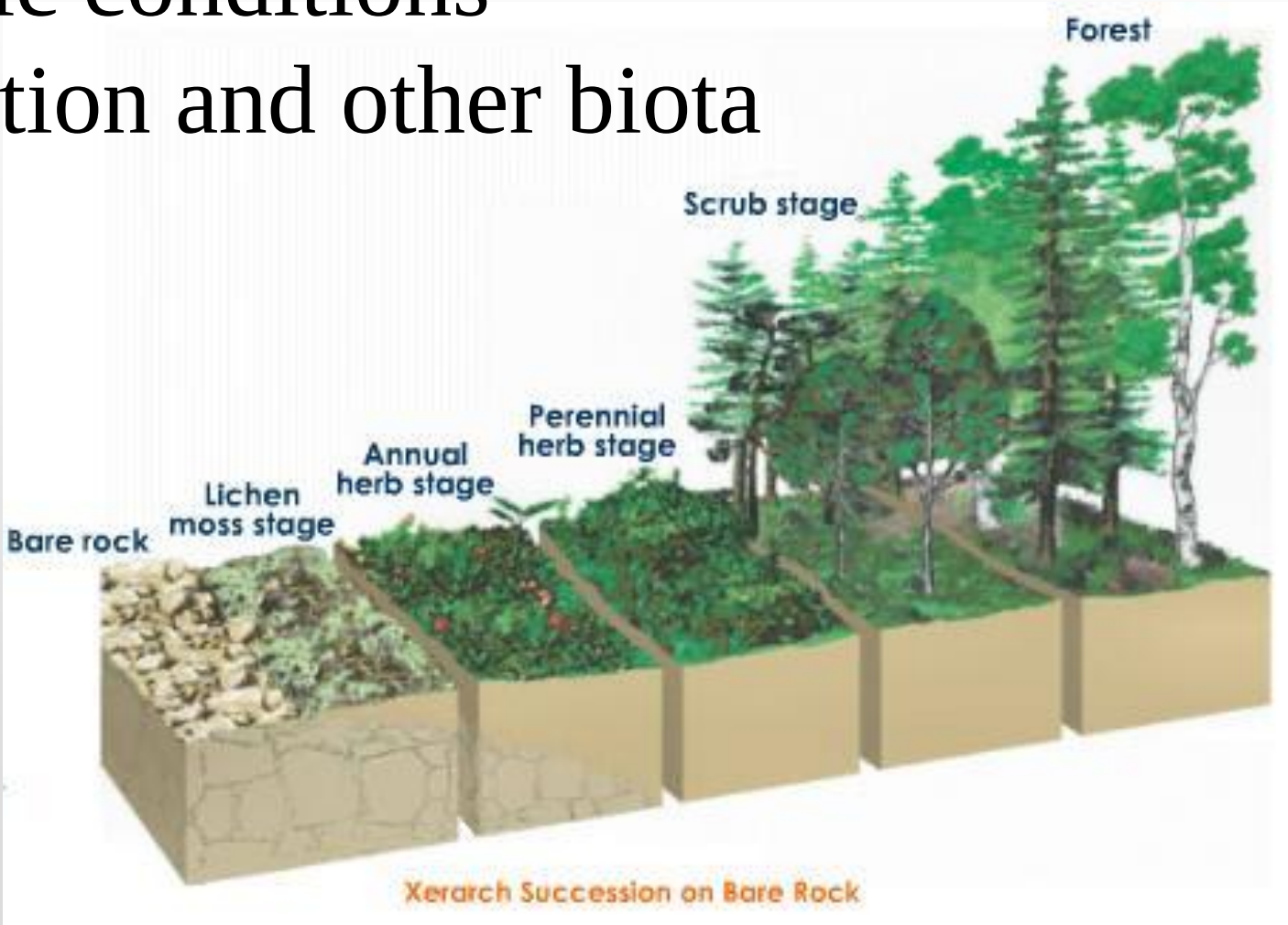
43

plant

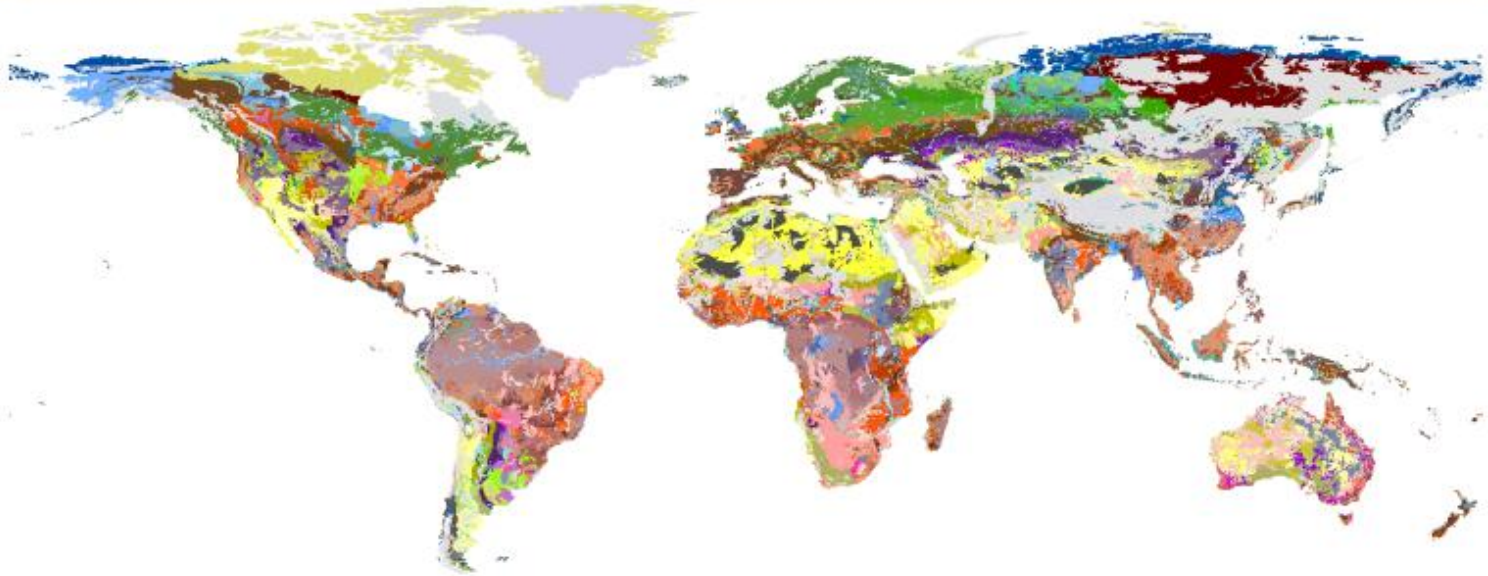
species

On few m^2 at least 170 species of soil eucaritic organism, but some groups neglected so realistically 2-3 times more.

Soil formation is affected by
geological substrate
climatic conditions
vegetation and other biota



Dominant Soils



Legend

VALUE

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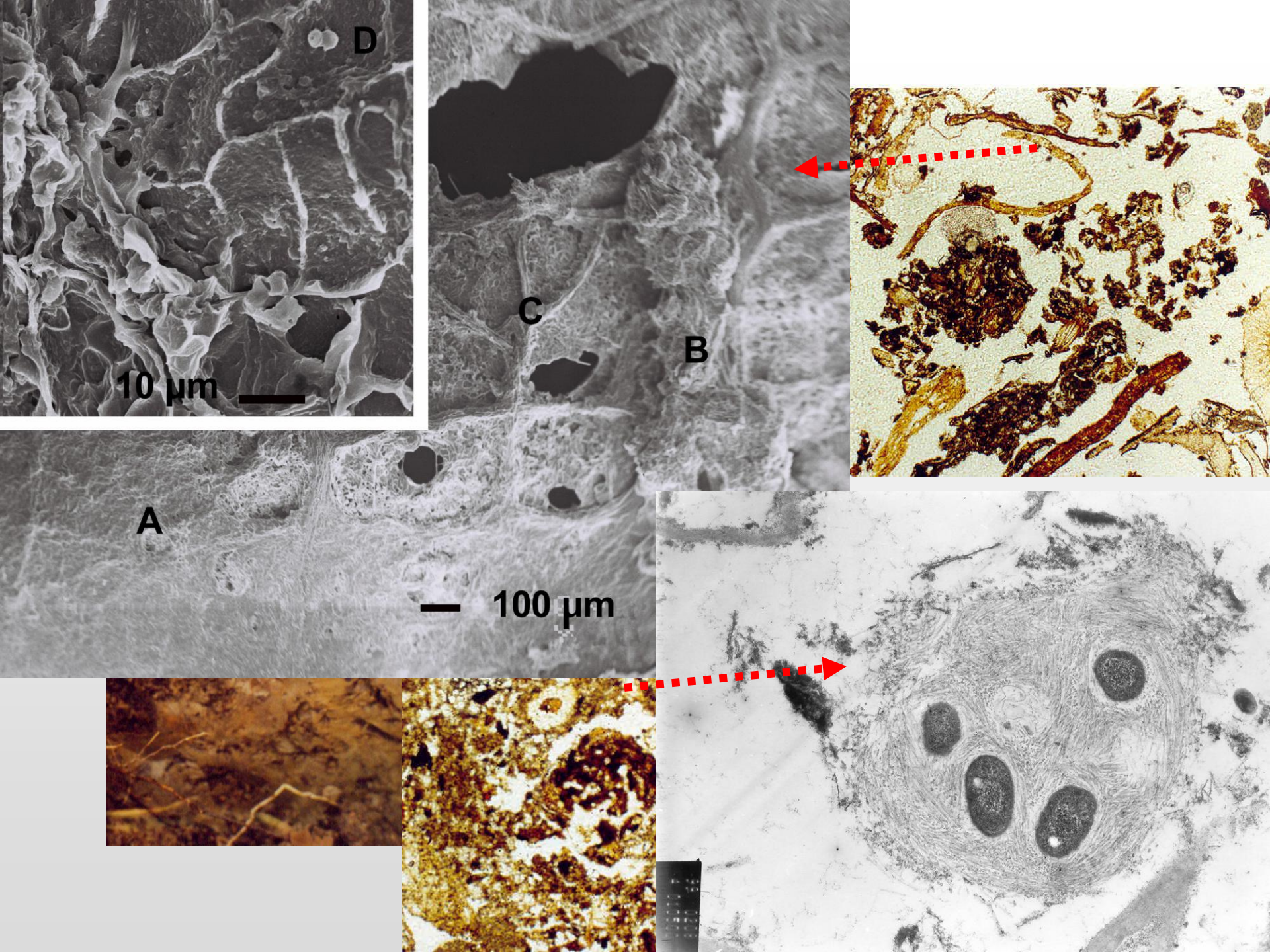
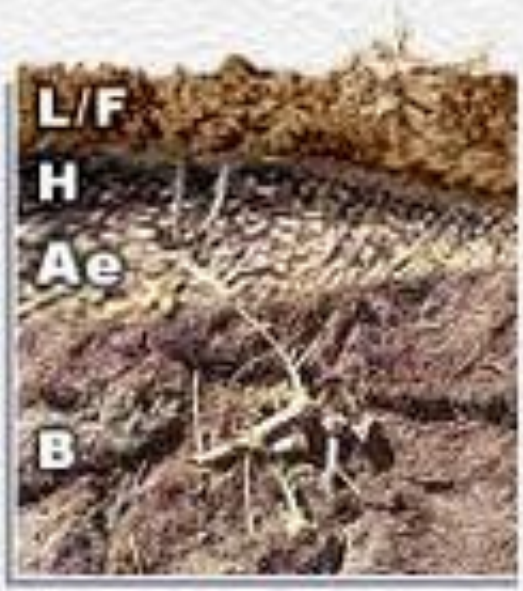
Source: FAO-UNESCO Soil Map of the World Geographic Projection AGL-2007


D
10 µm
C
B
A
100 µm

Humus foms

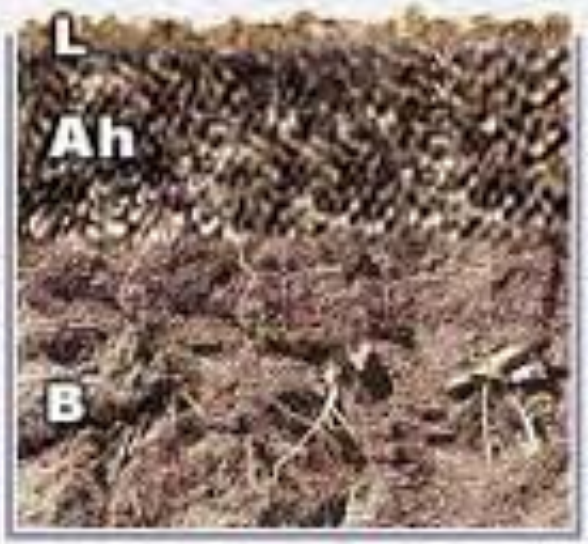


Mor

- matted F horizon
- abrupt boundary between mineral s and organic layer

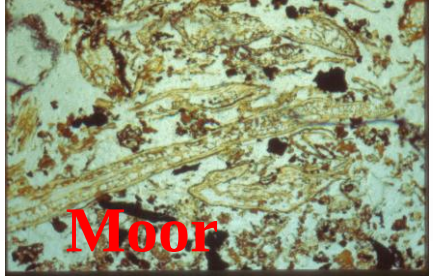
Moder

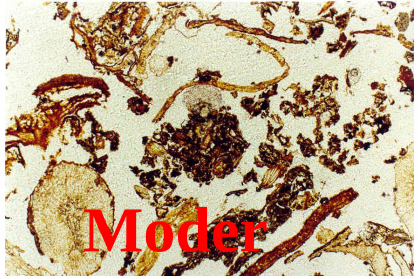
- loosely structured F horizon
- more gradual boundary between mineral soil and organic layers

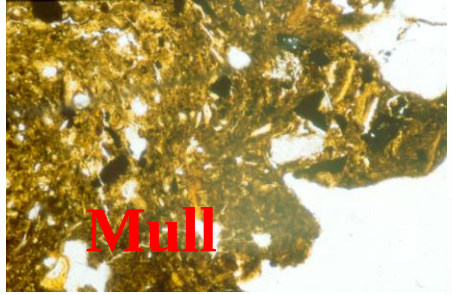


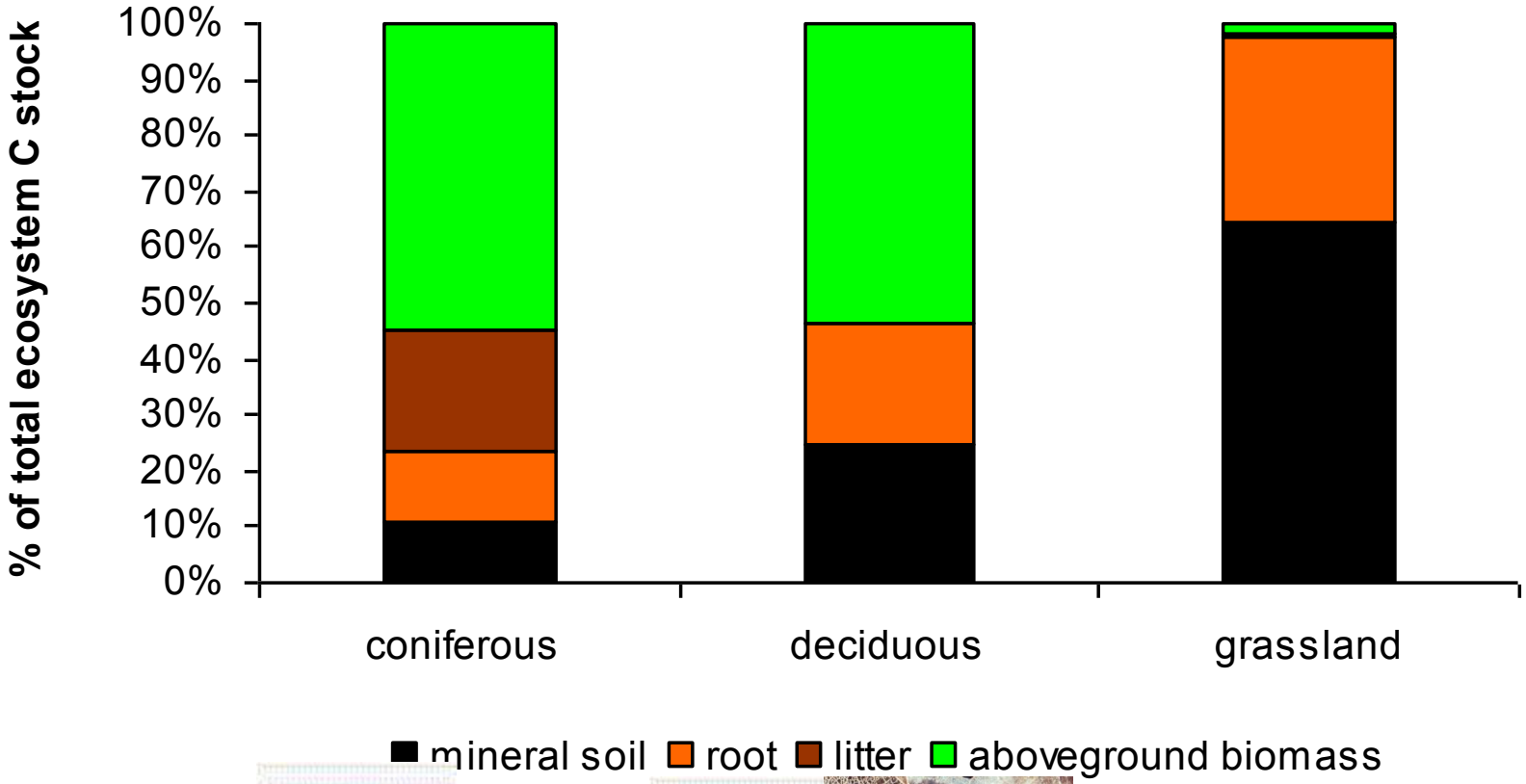
Mull

- F and H horizons thin or absent
- organic-enriched mineral soil horizon (Ah) present


Moor


Moder


Mull


% of total ecosystem C stock
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
coniferous
deciduous
grassland
mineral soil
root
litter
aboveground biomass


Spodosoils


Alfisoils

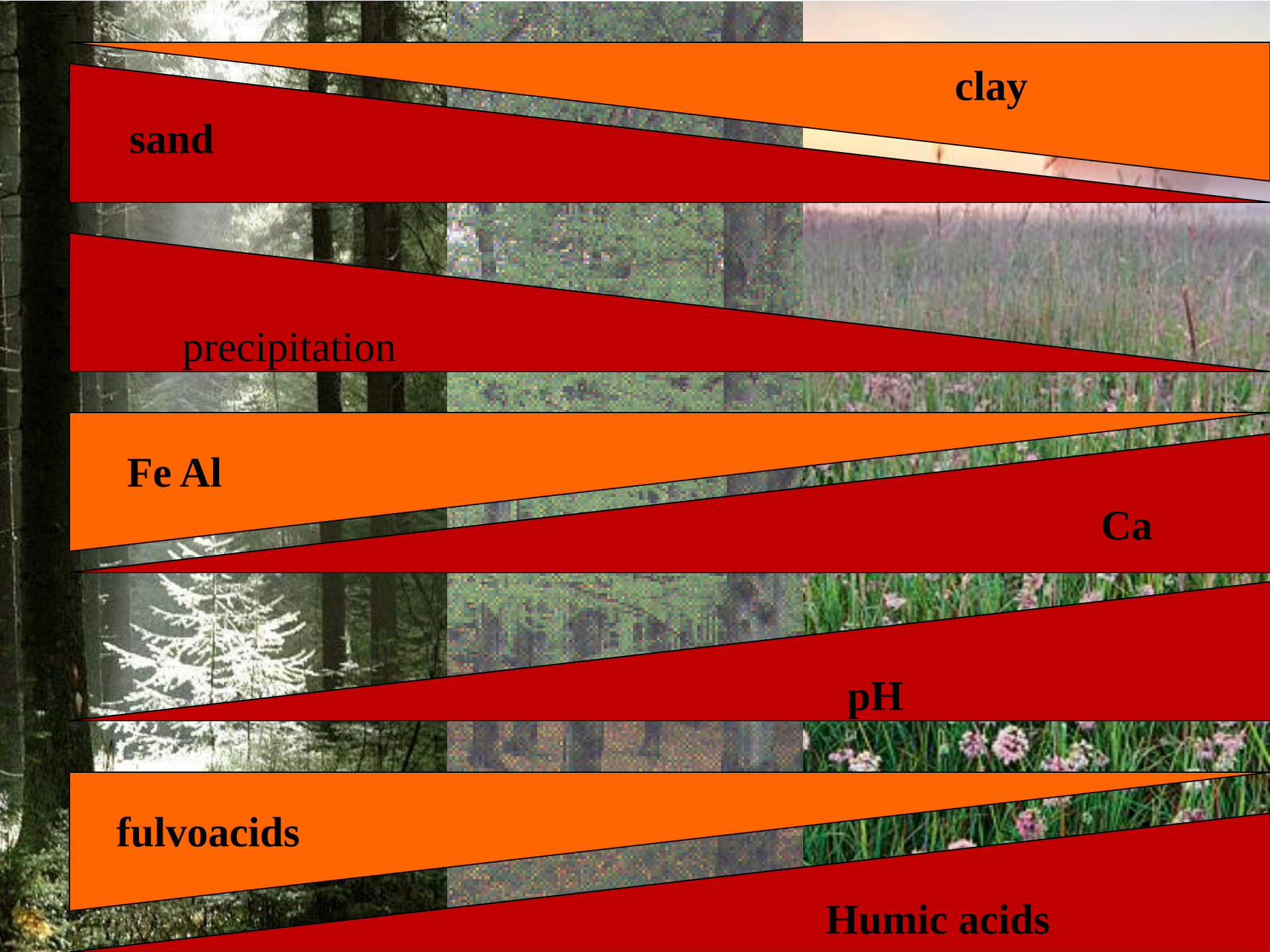

Molisoils


Moor
Moder
Mull
Spodosoils
Podzol
Alfisoils
Luvisol
Molisoils
Chernozem
Vertisol tropic

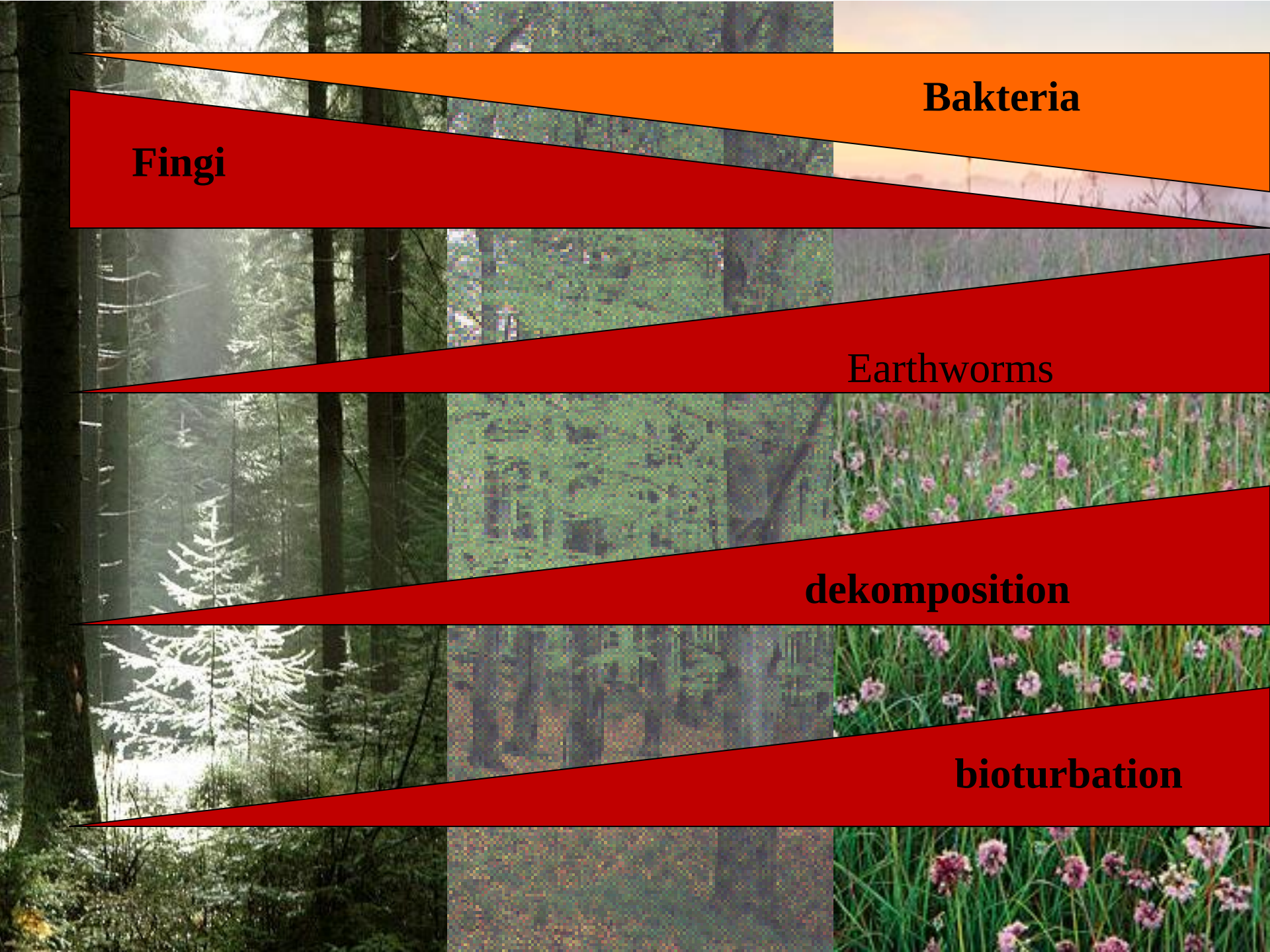

Moor


Moder

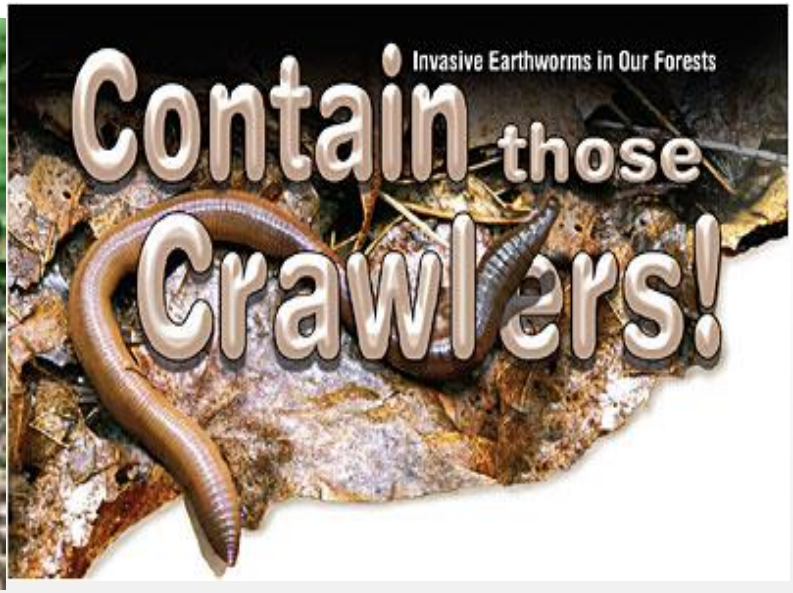

Mull


clay
sand
precipitation
Fe Al
Ca
pH
fulvoacids
Humic acids


C/N
Lignin/N
Annual litter input


Bakteria
Fingi
Earthworms
dekomposition
bioturbation

Evropean Worms in North America



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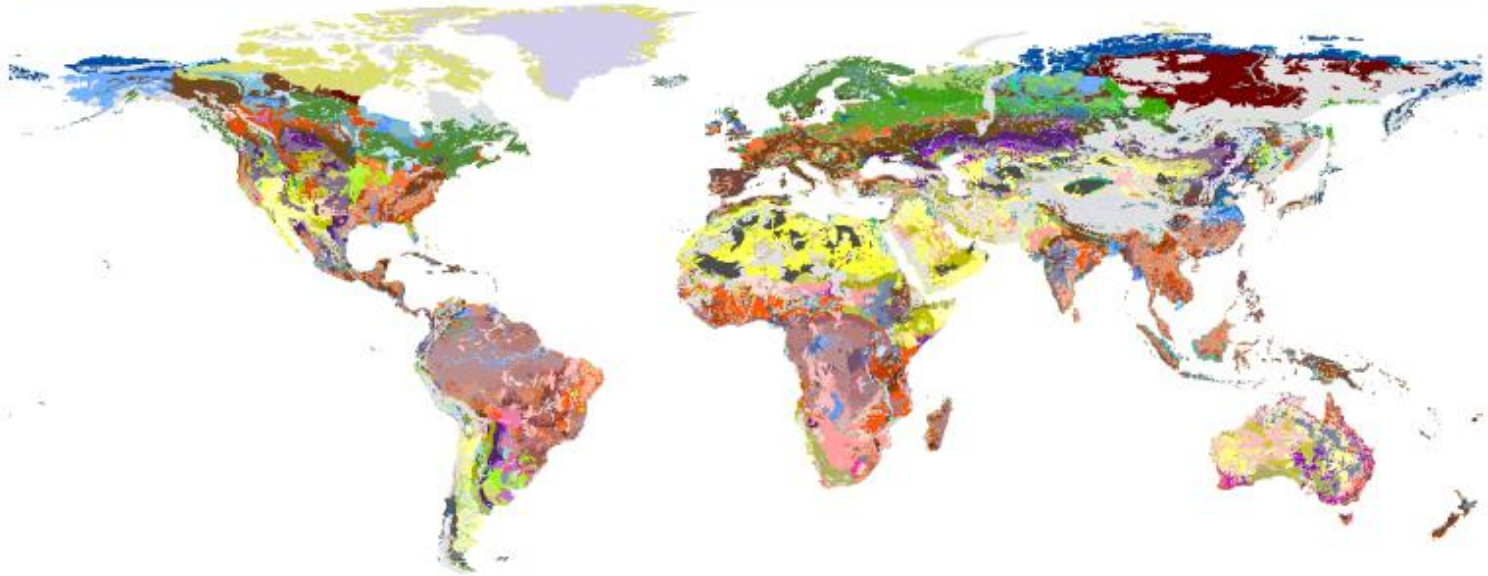

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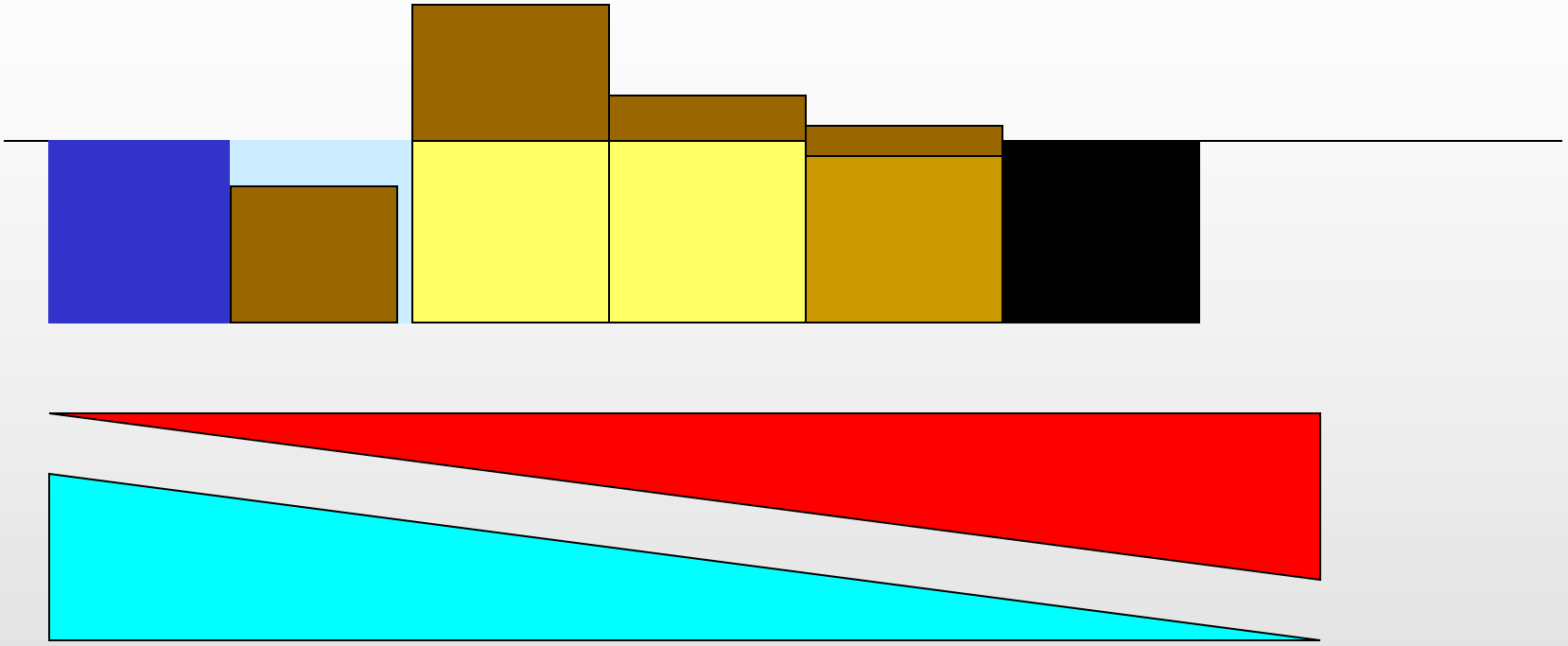
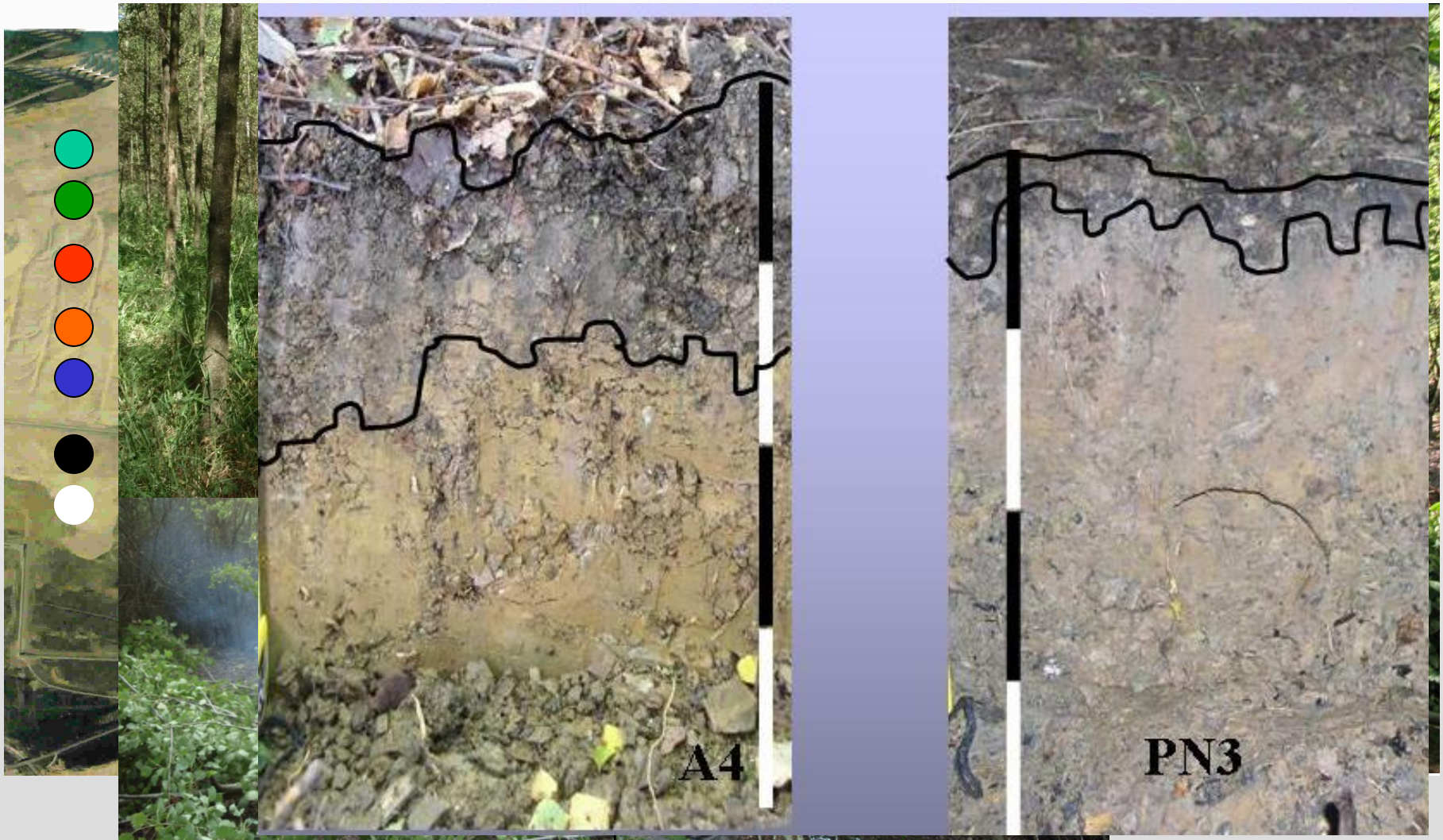
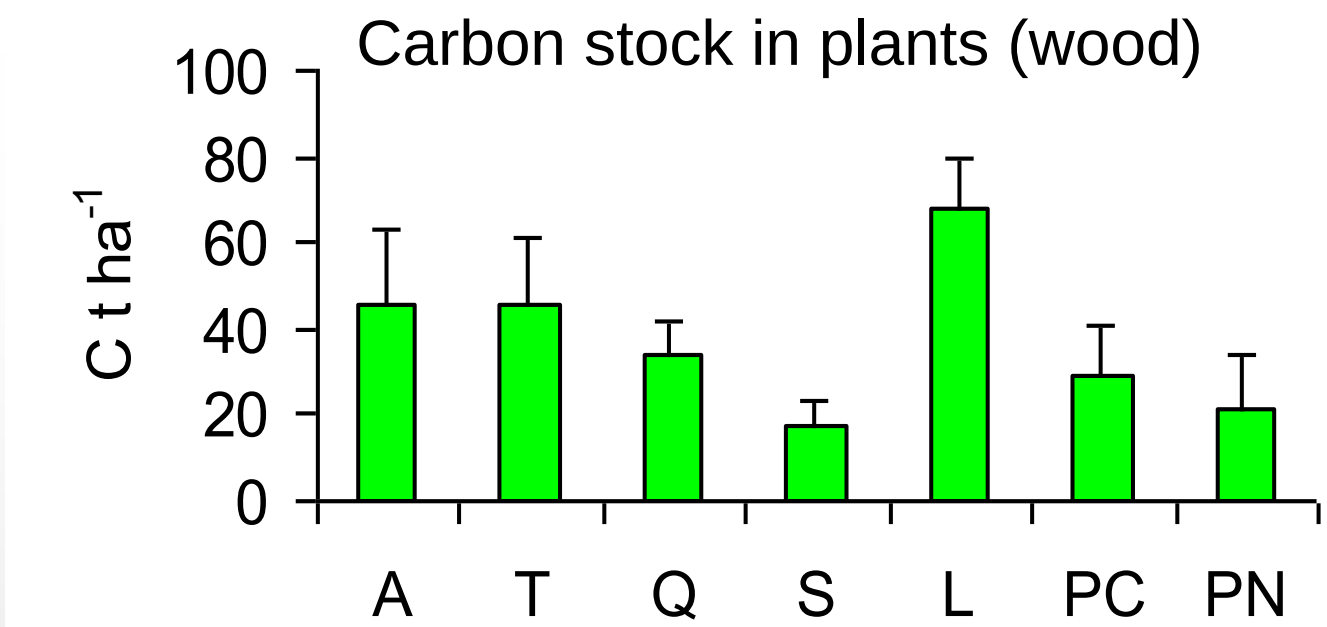
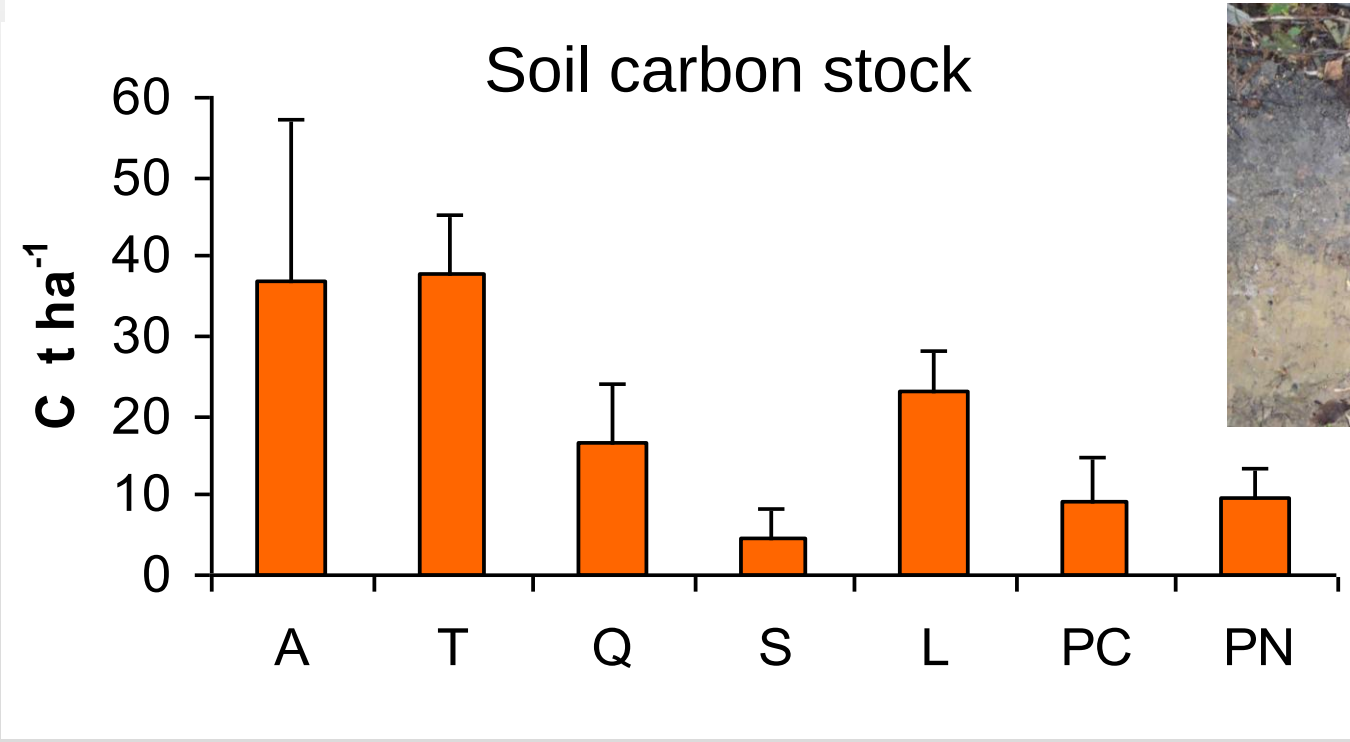
Frost floding water percolation evaporation



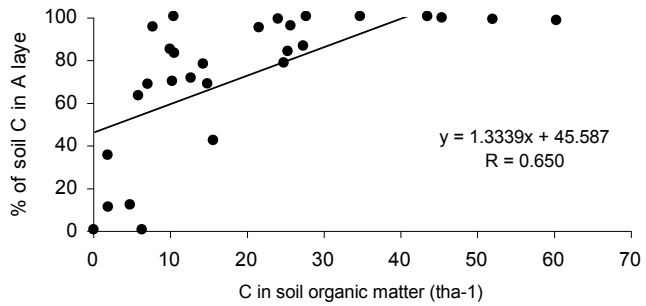
Comparison of soil development under various plantations.

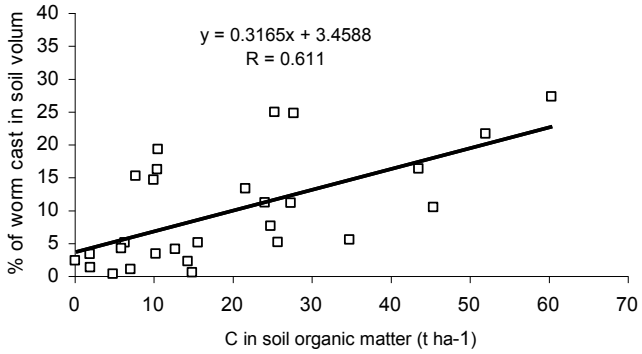


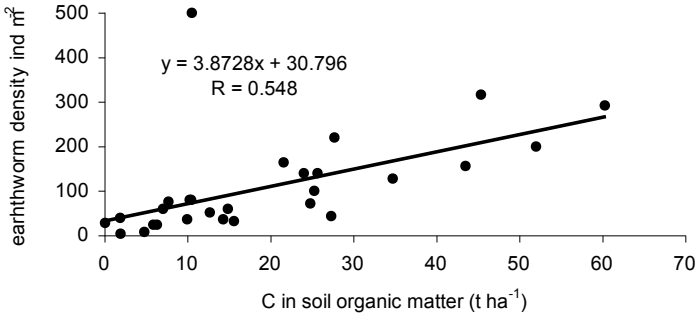


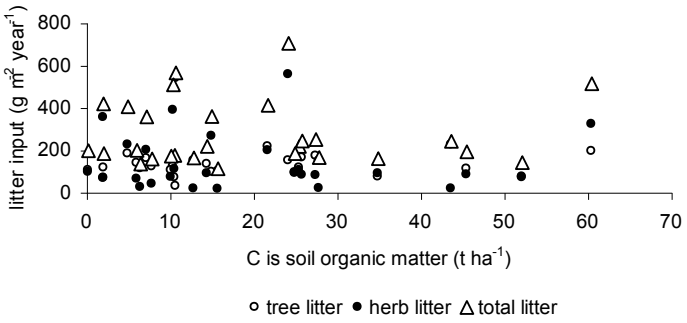


22-32 year old sites

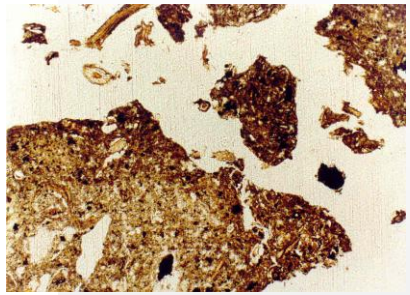

% of soil C in A laye
y = 1.3339x + 45.587
R = 0.650
C in soil organic matter (tha-1)


% of worm cast in soil volum
y = 0.3165x + 3.4588
R = 0.611
C in soil organic matter (t ha-1)


earthworm density ind m2
y = 3.8728x + 30.796
R = 0.548
C in soil organic matter (t ha-1)


litter input (g m2 year-1)
C is soil organic matter (t ha-1)
tree litter
herb litter
total litter


LF (Oa Oe)
A



Location of study area and pictures of spontaneously developing sites (age of 11, 15 and 41 years).

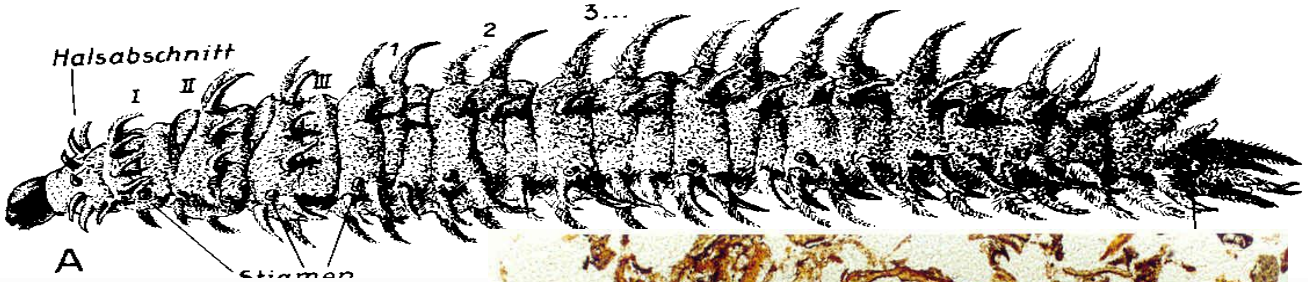


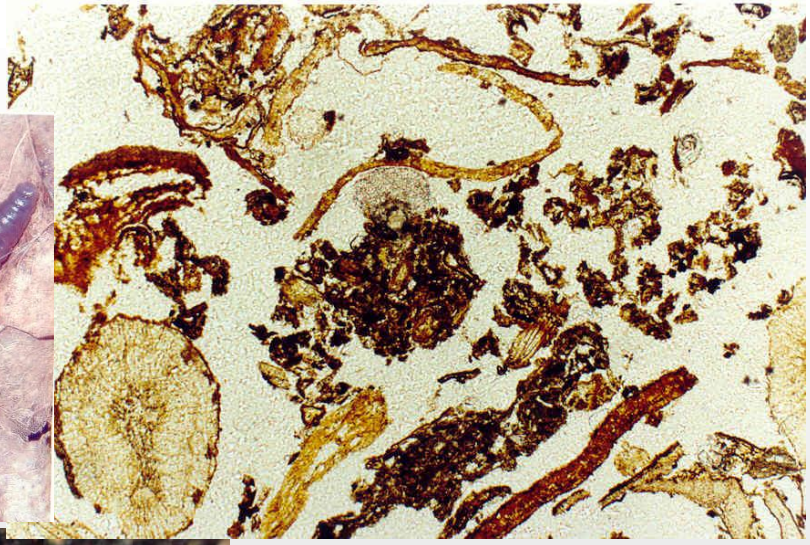
Reclaimed sites (alder plantations) heaped 14, 23 and 42 years ago

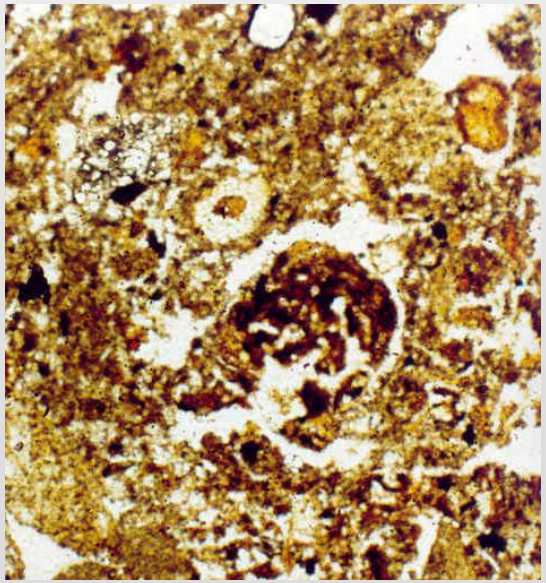
reclaimed

unreclaimed

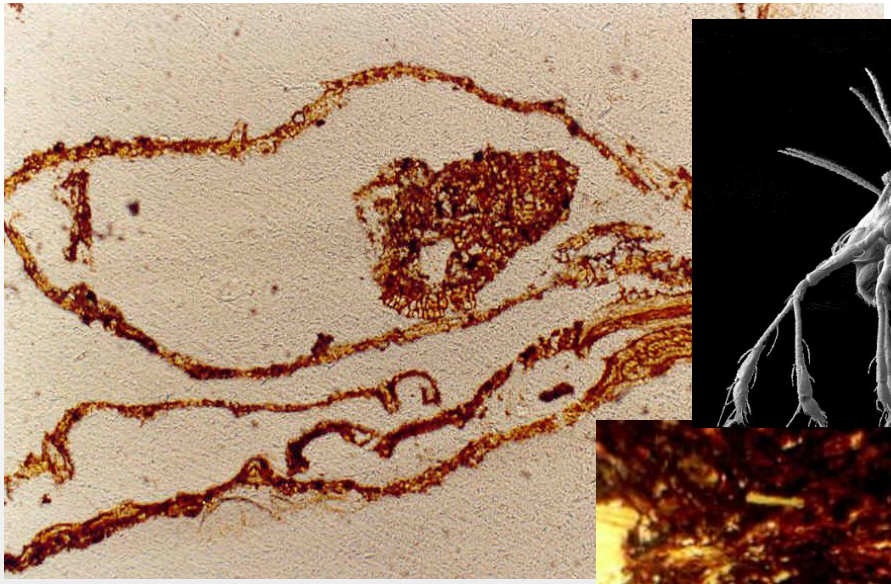
Reclaimed site
20 year old

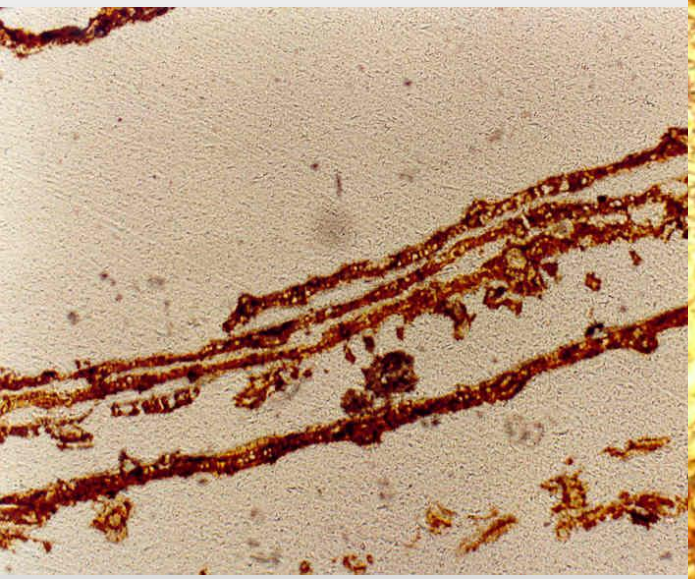


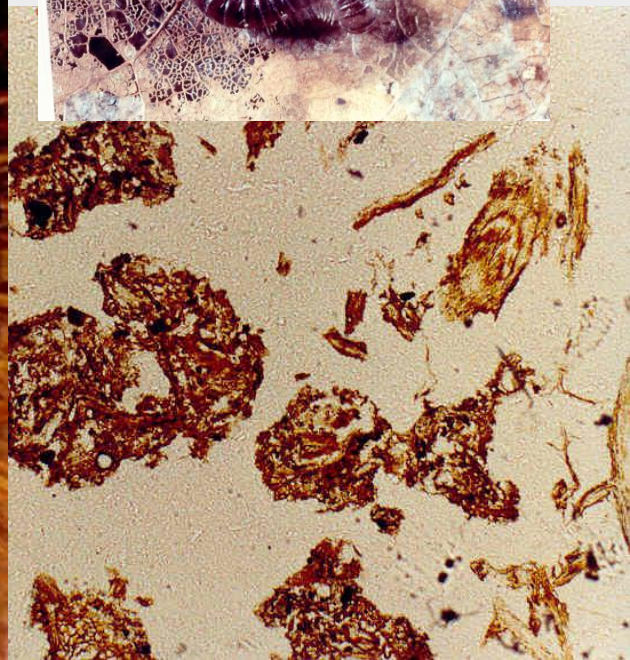




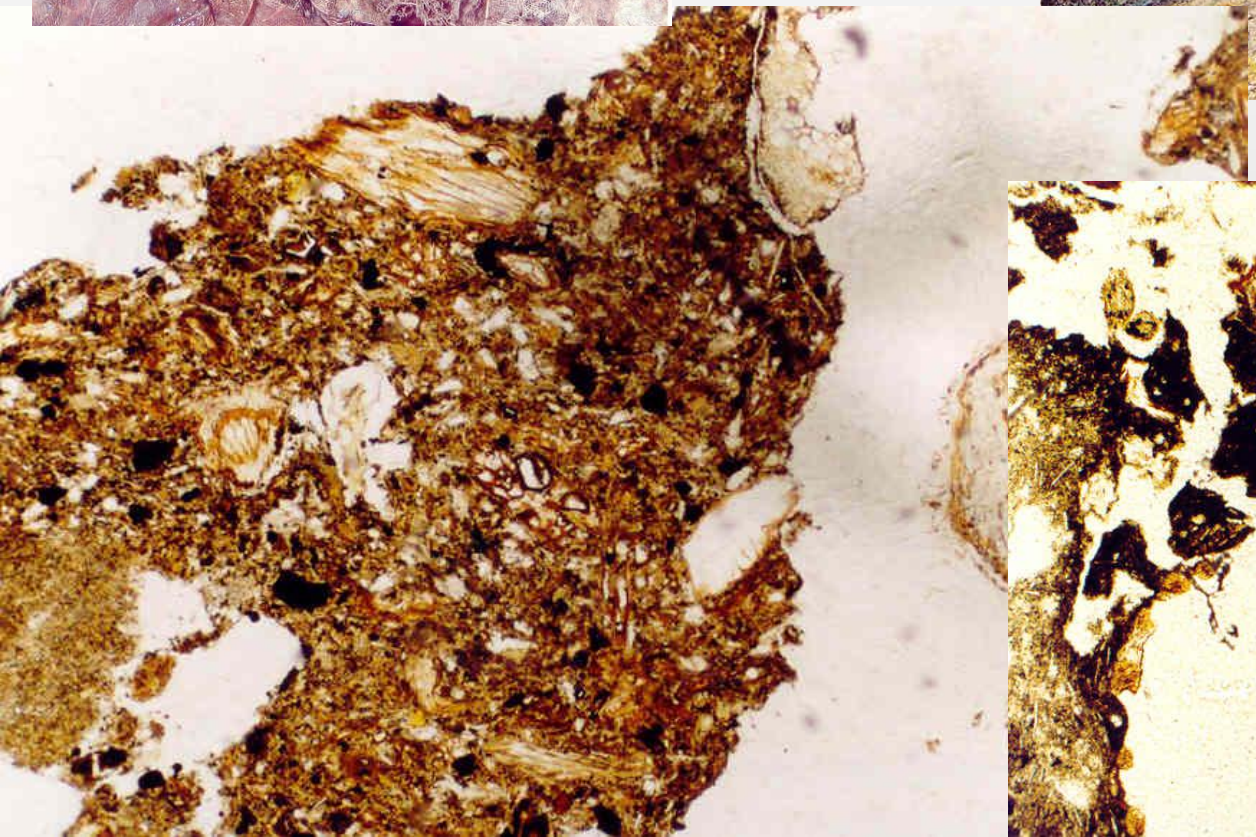
Spontaneous succession - unreclaimed 20 year old

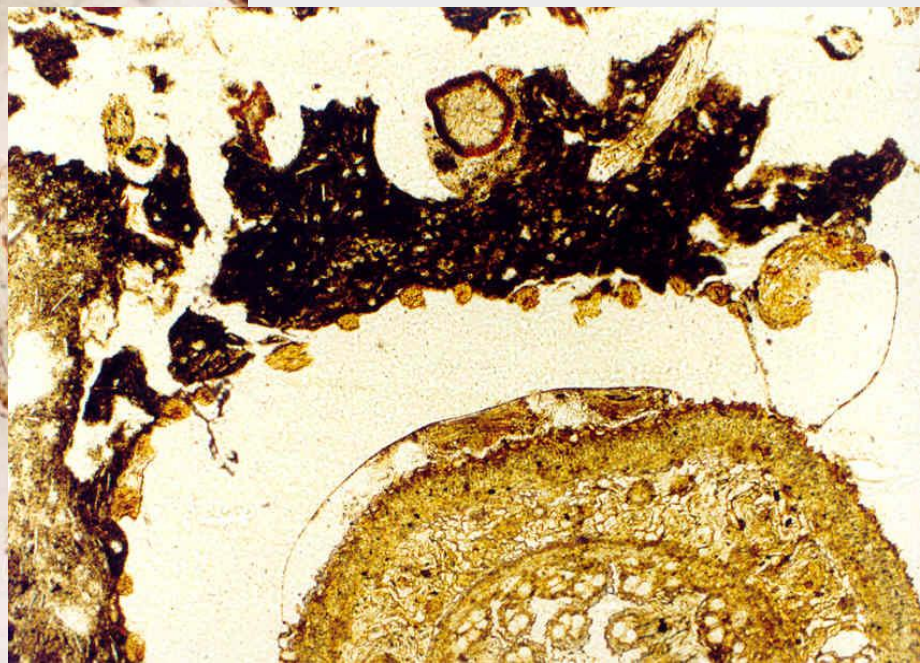


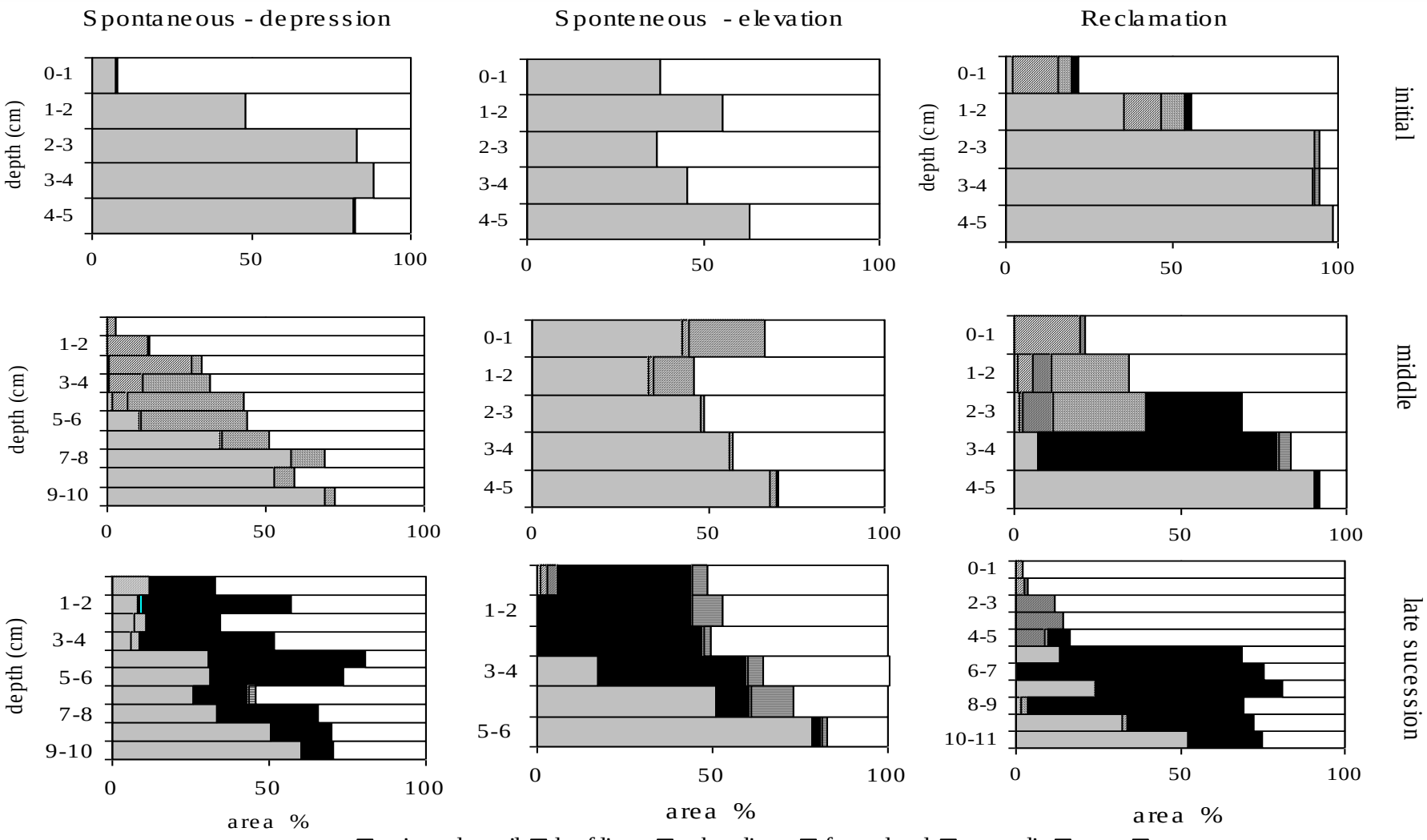


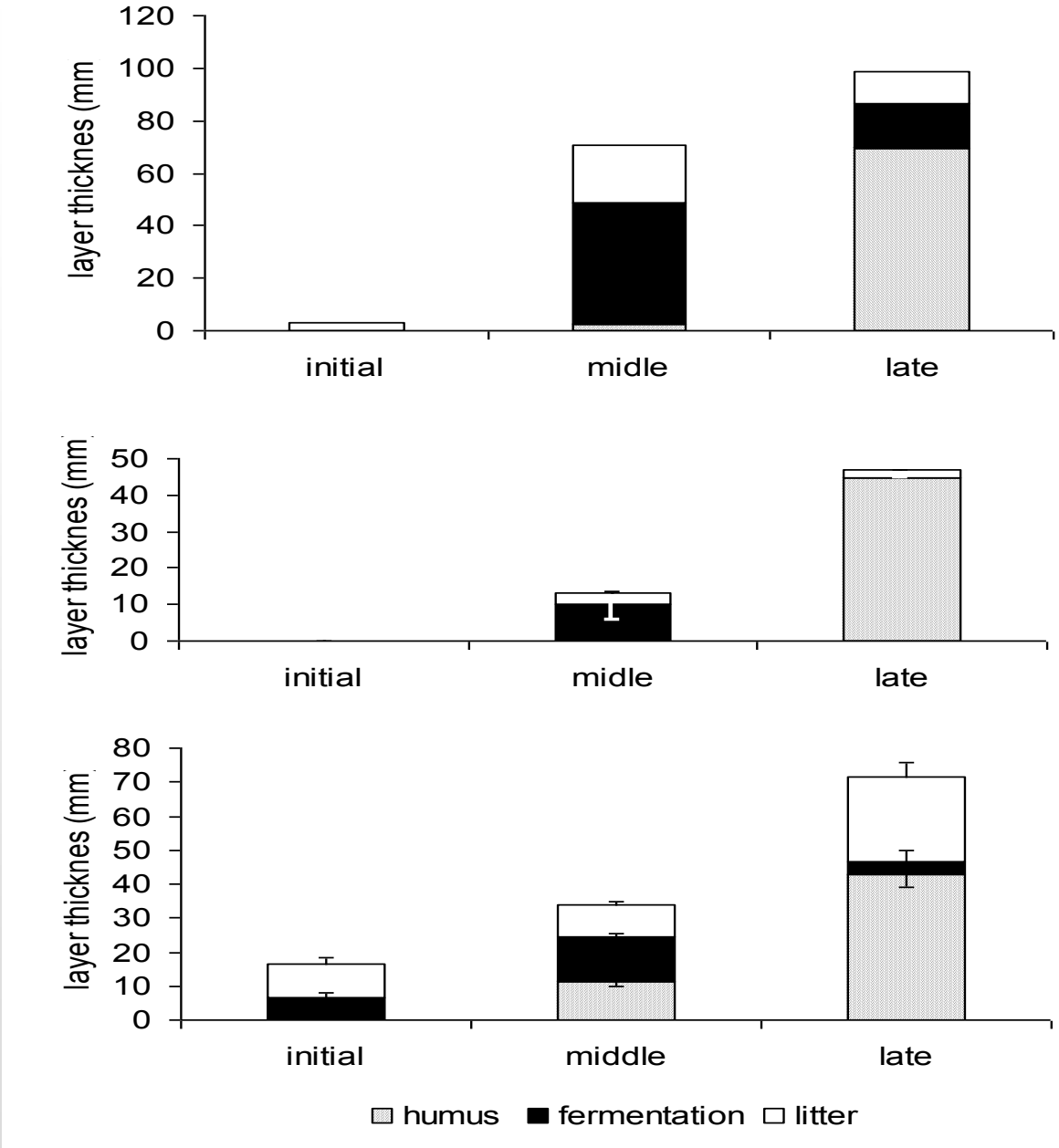


Spontaneous succession - 40 years old plot

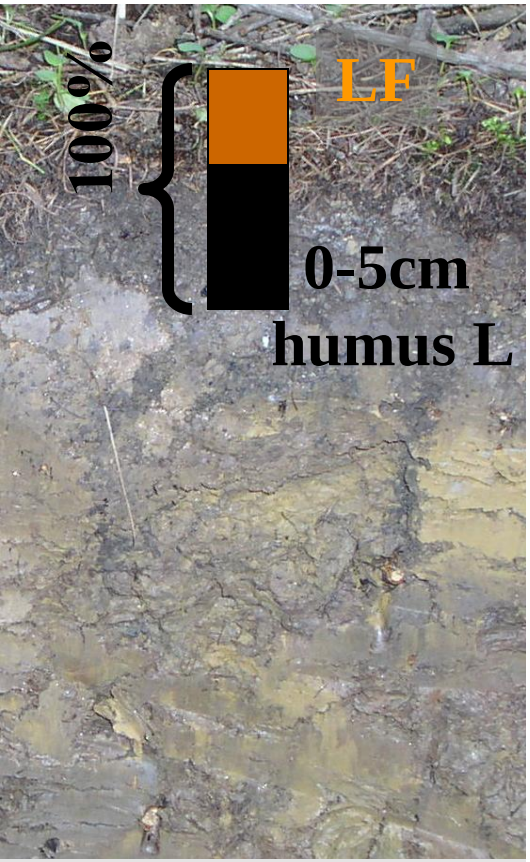


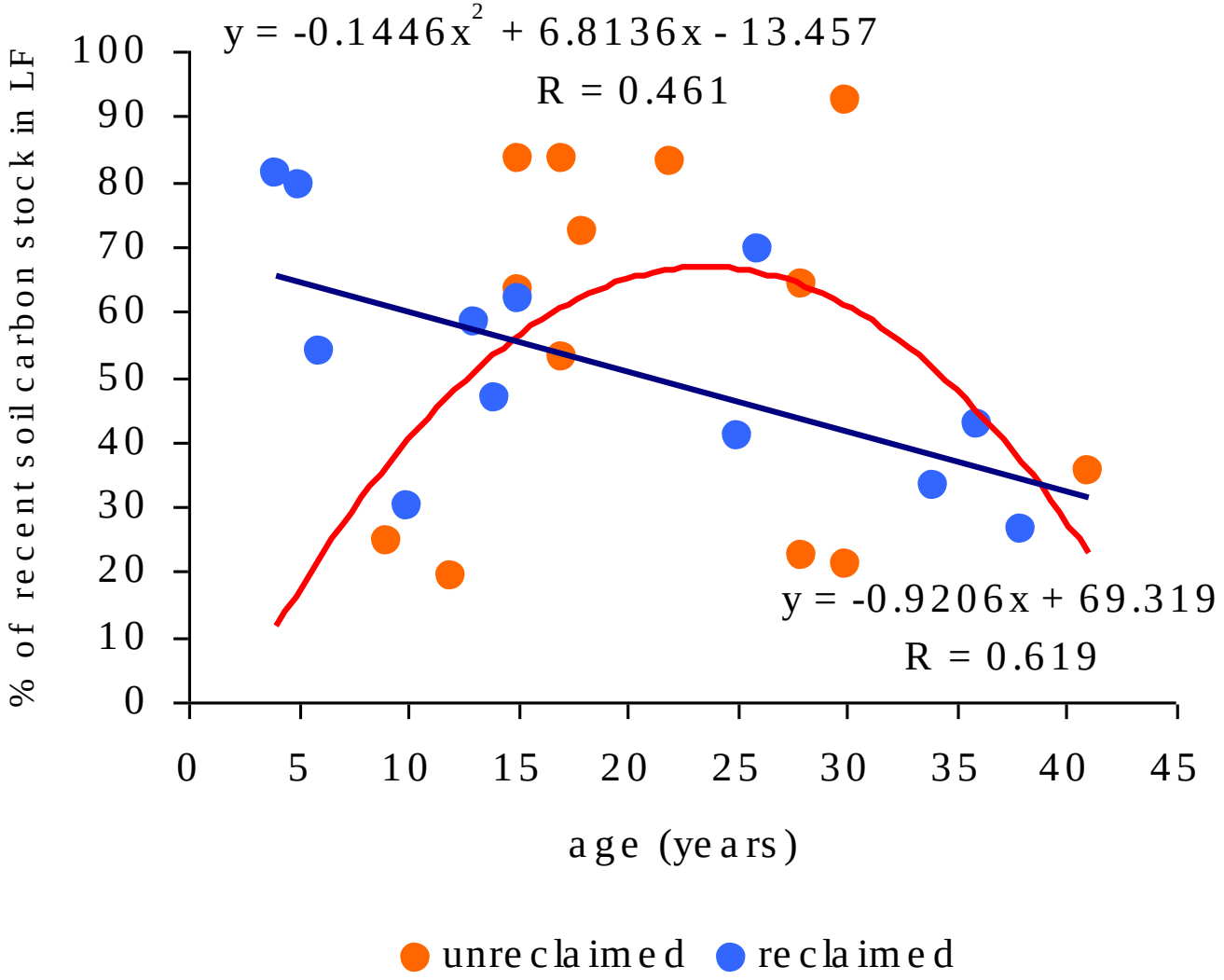



Spontaneous - depression
Sponteneous - elevation
Reclamation
initial
middle
late sucession
depth (cm)
0-1
1-2
2-3
3-4
4-5
5-6
7-8
9-10
10-11
0
50
100
area %
mineral spoil
leaf litter
other litter
faecal pel
coprolit
root
pores

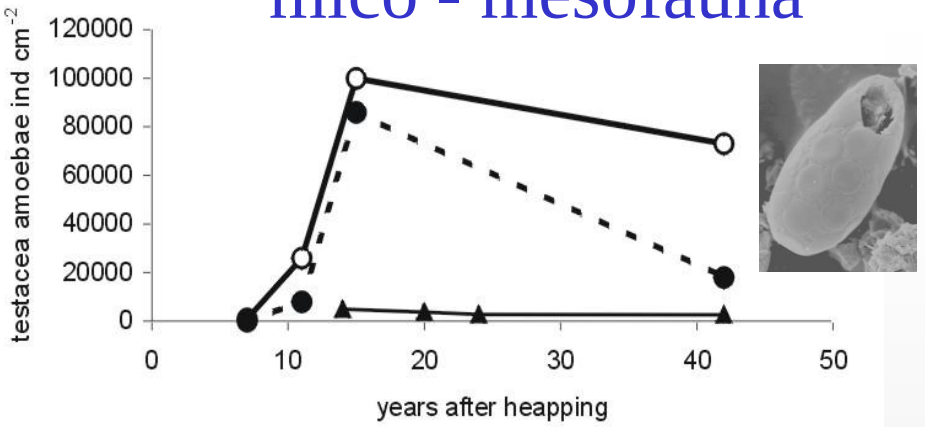

120
100
80
60
40
20
0
layer thicknes (mm
initial
midle
late
50
40
30
20
10
0
layer thicknes (mm
initial
midle
late
80
70
60
50
40
30
20
10
0
layer thicknes (mm
initial
middle
late
humus
fermentation
litter

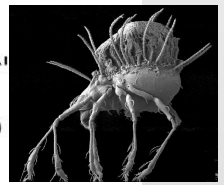
Distribuce zásoby C mezi nadzemní a mělkou podzemní část

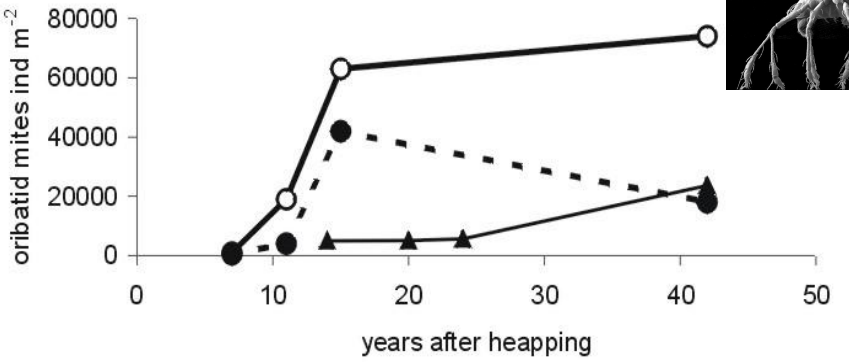




Soil fauna macrofauna mico - mesofauna

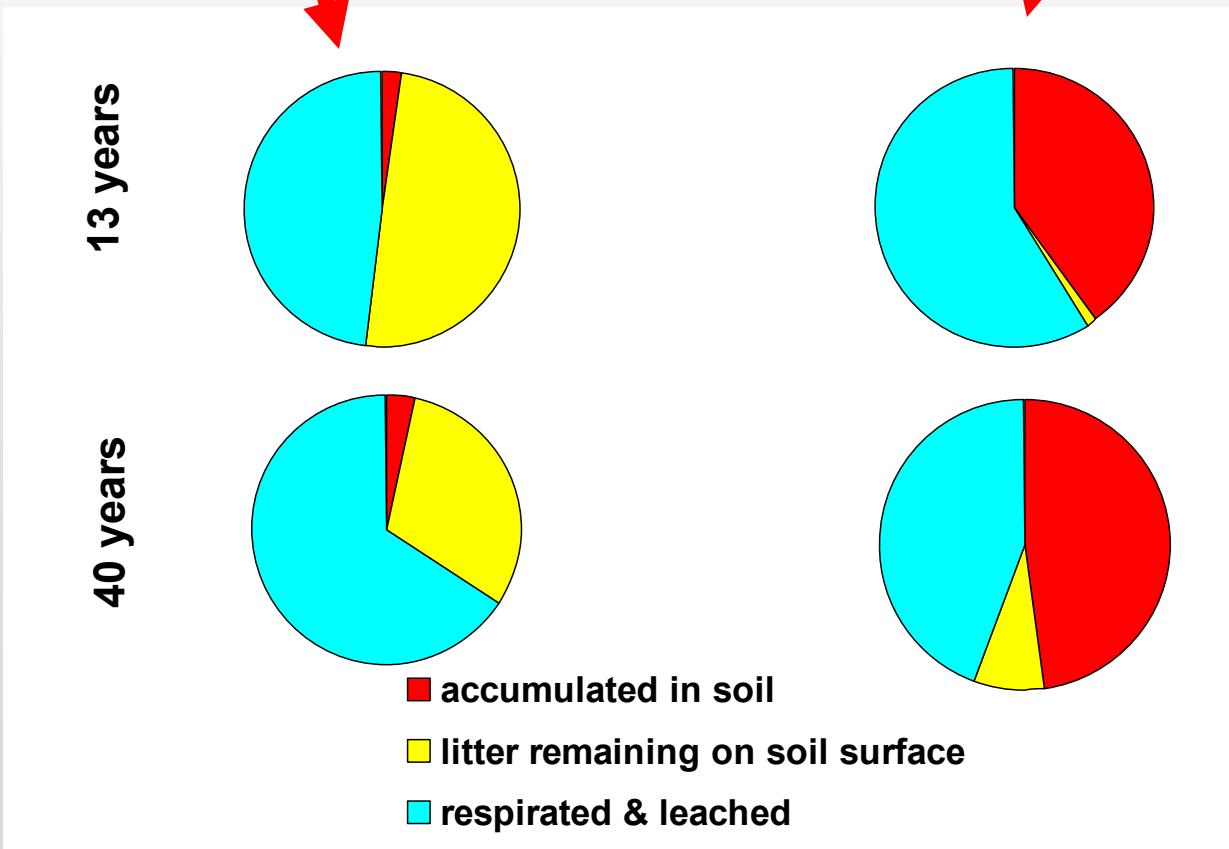


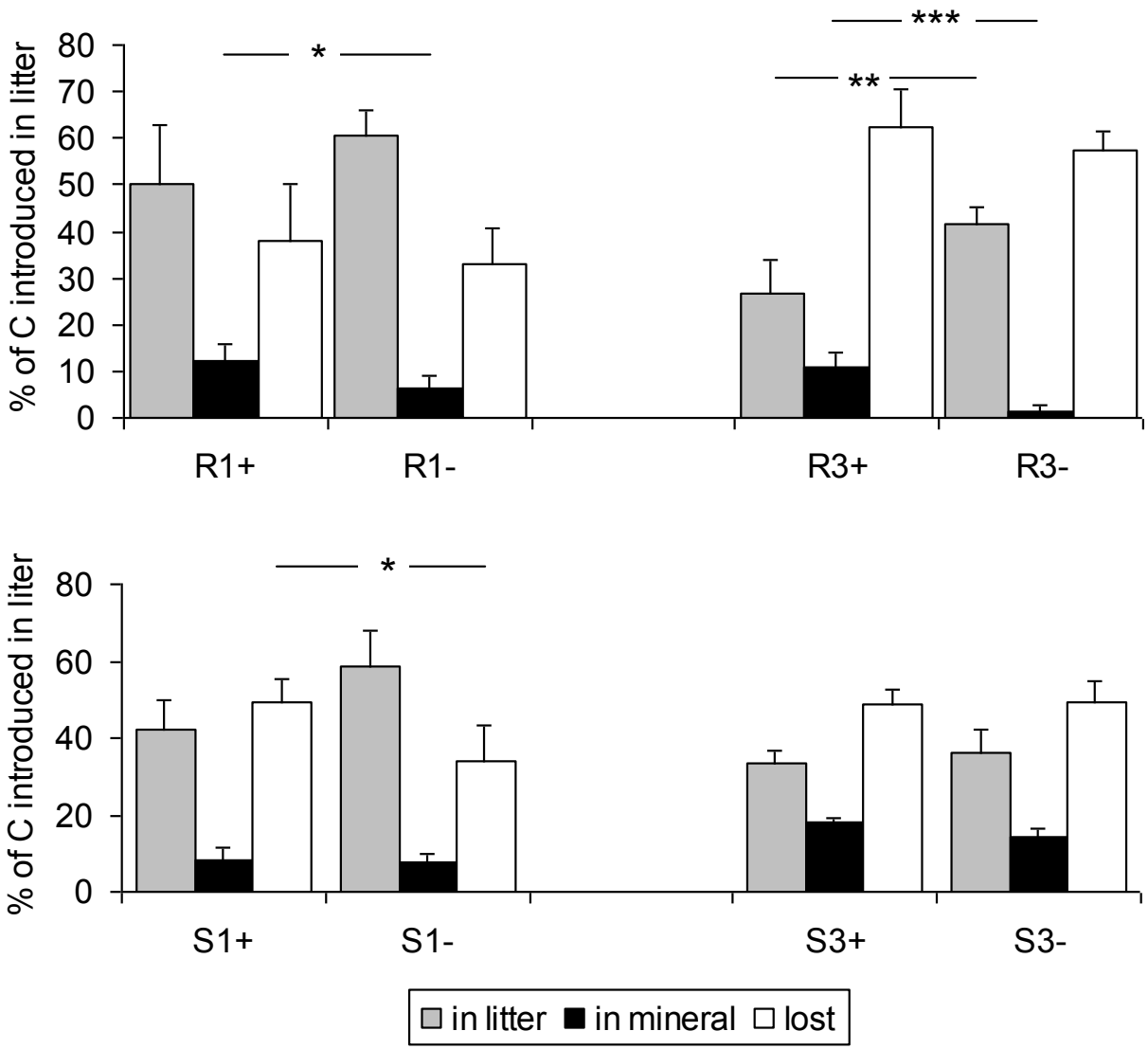




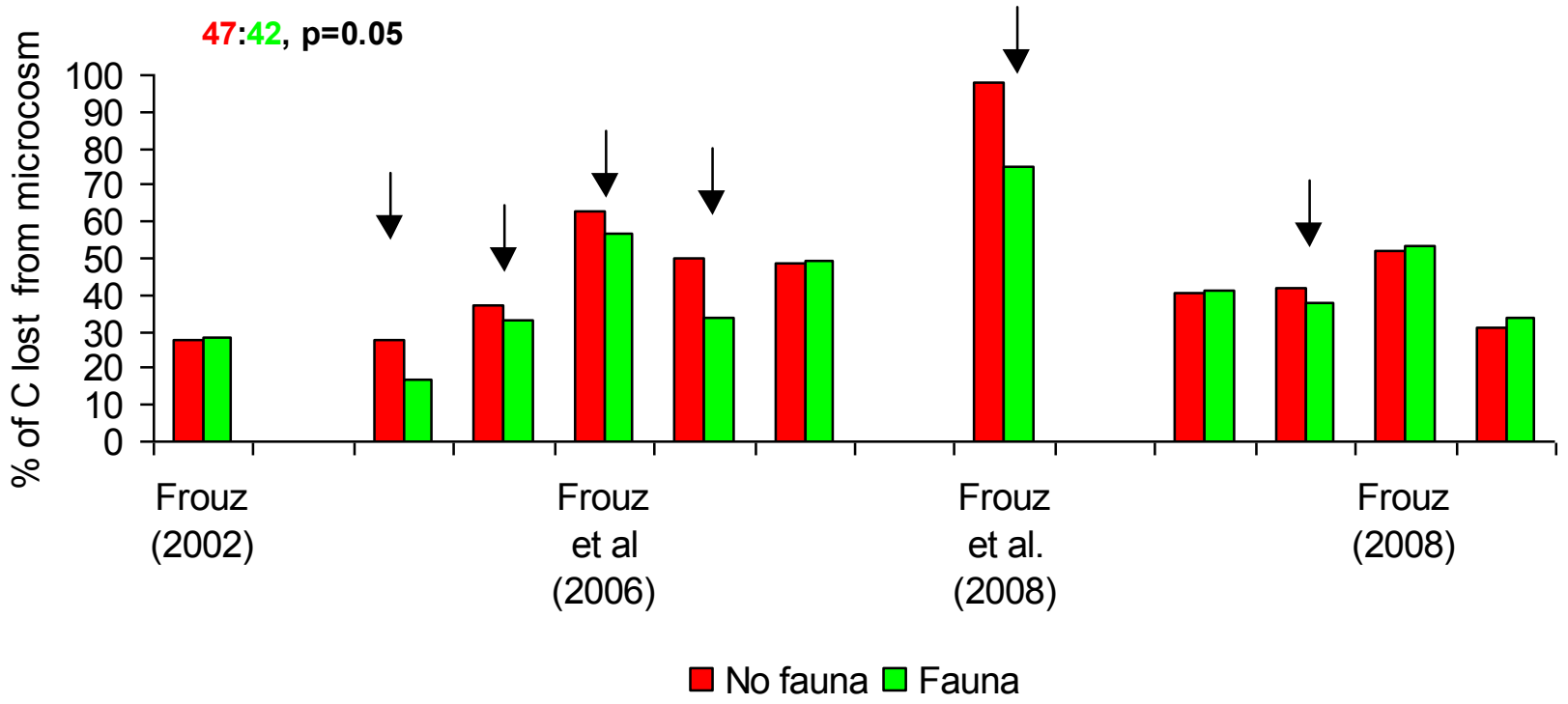
Macrofauna excluded

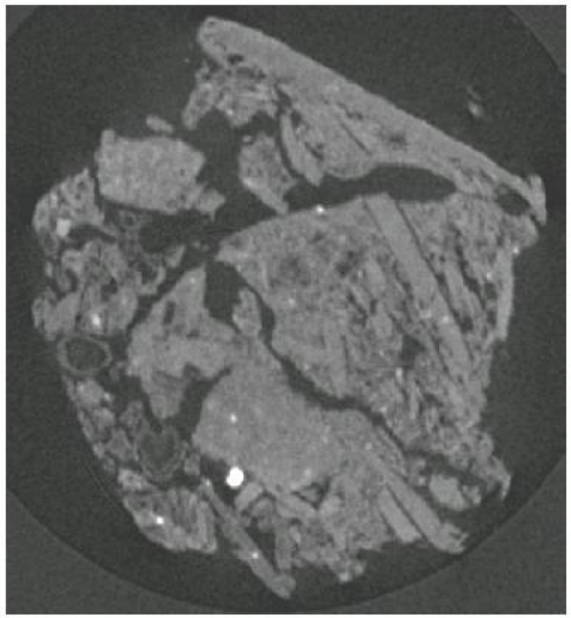
Accessible for macrofauna



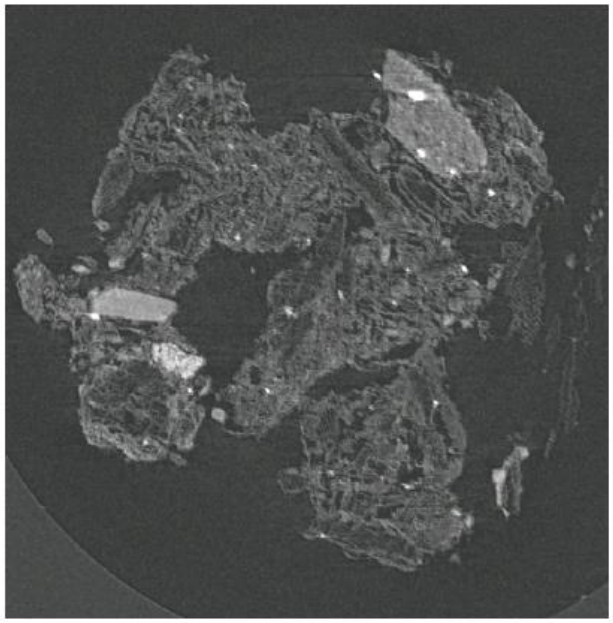


	liter removal	C acc in min layer	mineralisation
vegetation	ns	**	**
time	**	**	**
fauna	**	**	ns


47:42, p=0.05
% of C lost from microcosm
100
90
80
70
60
50
40
30
20
10
0
Frouz (2002)
Frouz et al (2006)
Frouz et al. (2008)
Frouz (2008)
No fauna
Fauna



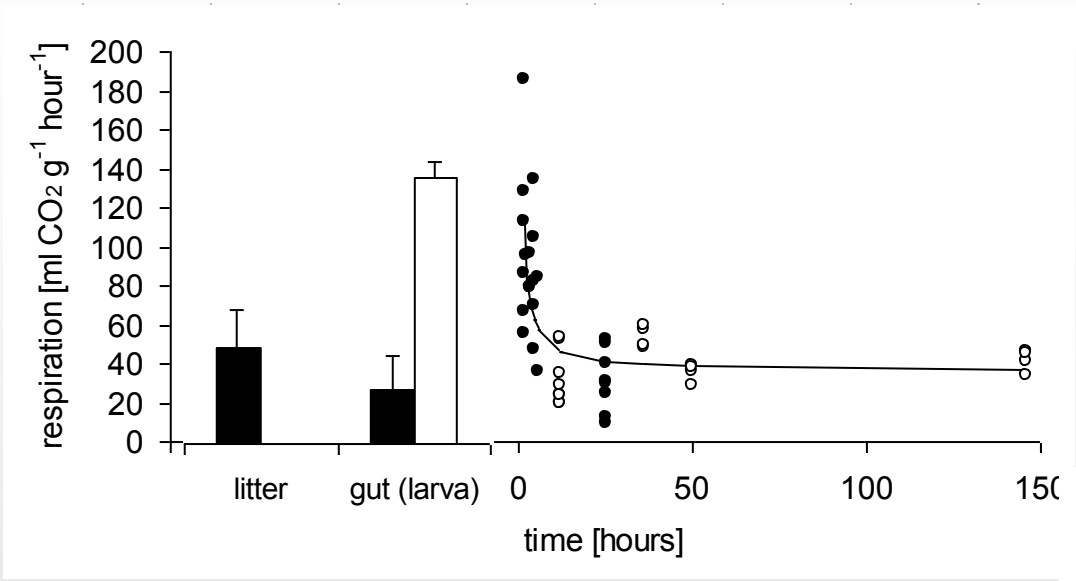
Other aggregates

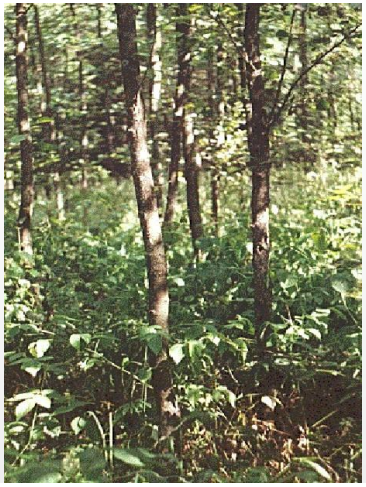


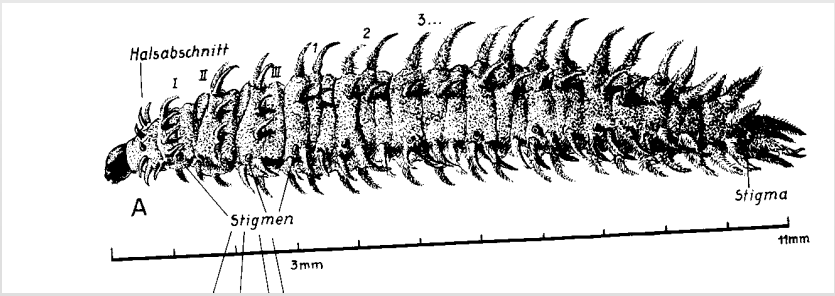
Earthworm created aggregates

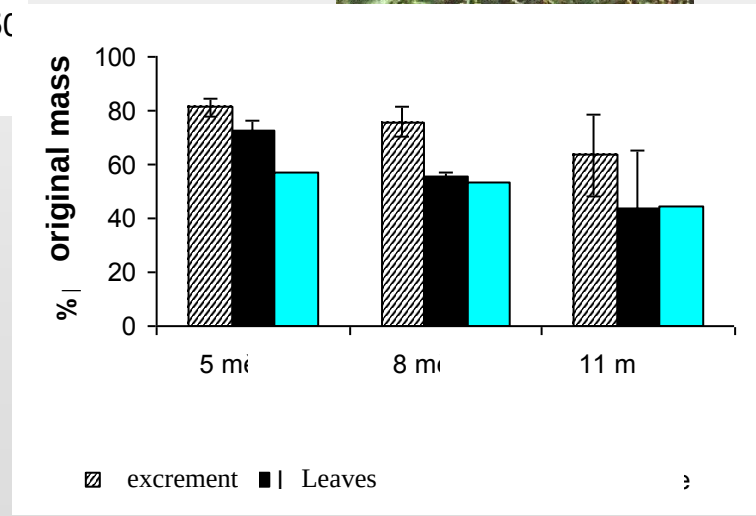
	prismatic	spherical
Light POM	0.34±0.21	0.84±0.55
Bounded light POM	0.18±0.12*	1.34±0.43*

In short term gut passage increased microbial respiration of excrement



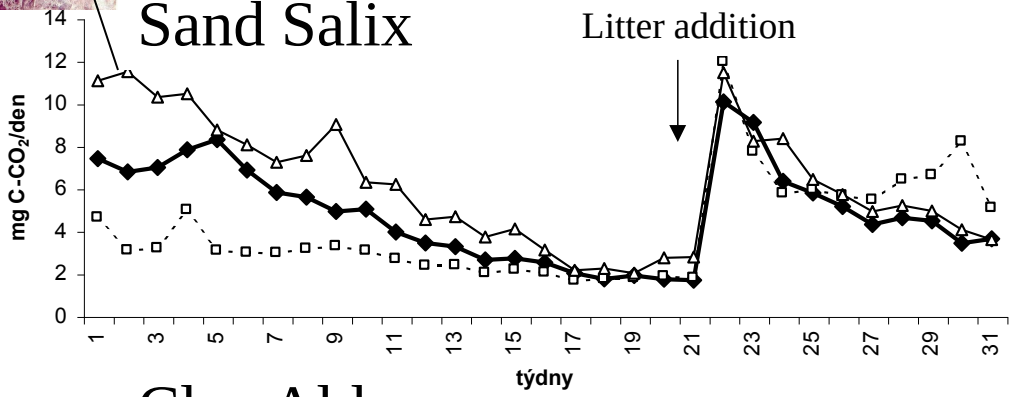




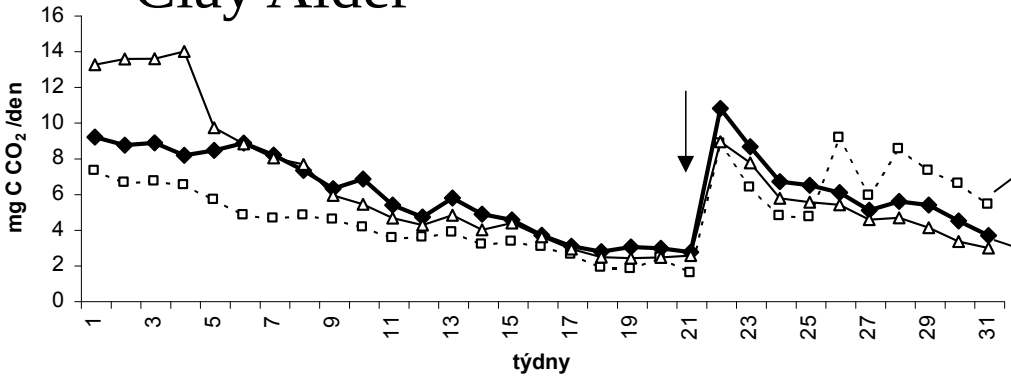


Sand Salix

Litter addition



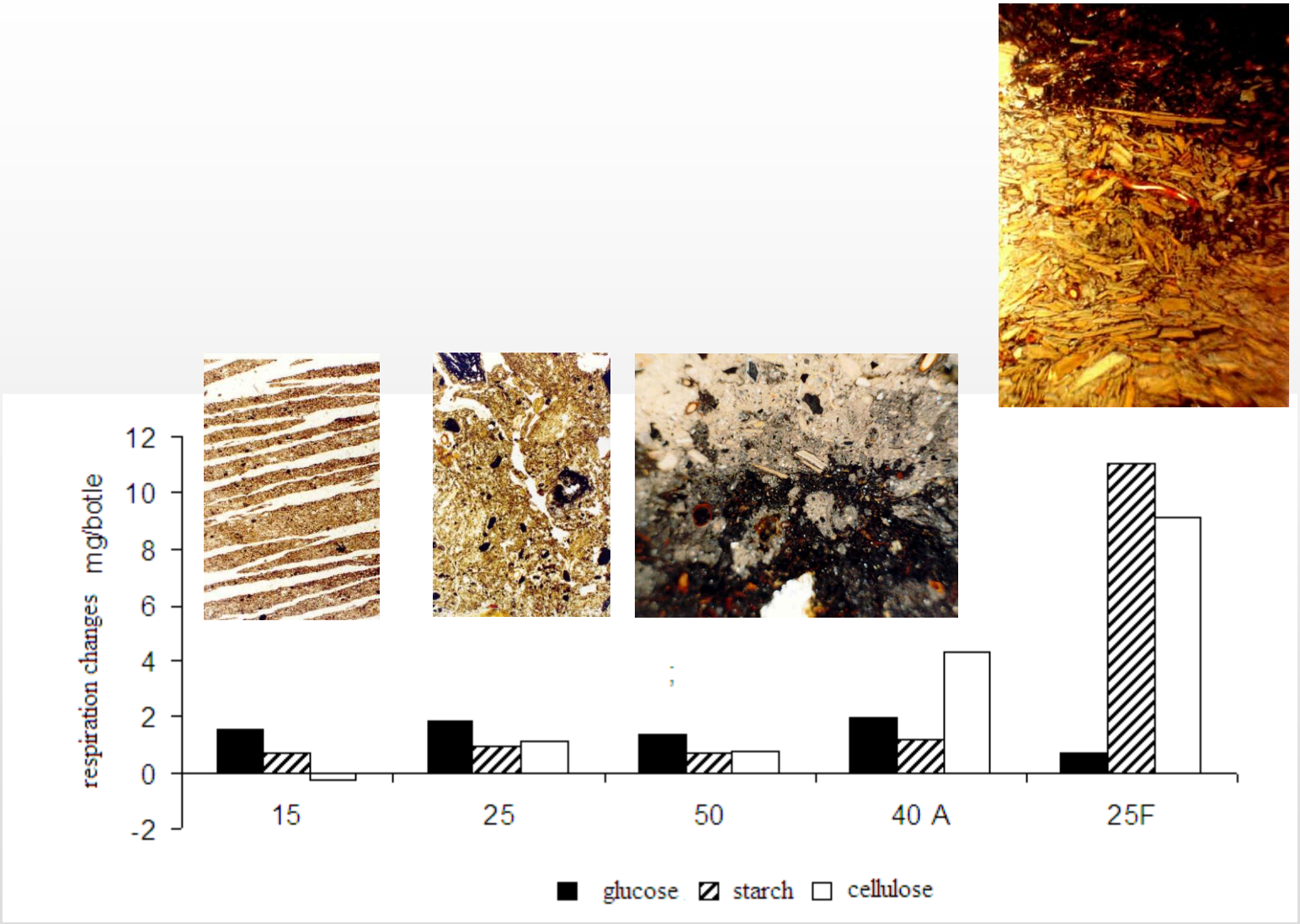
Clay Alder

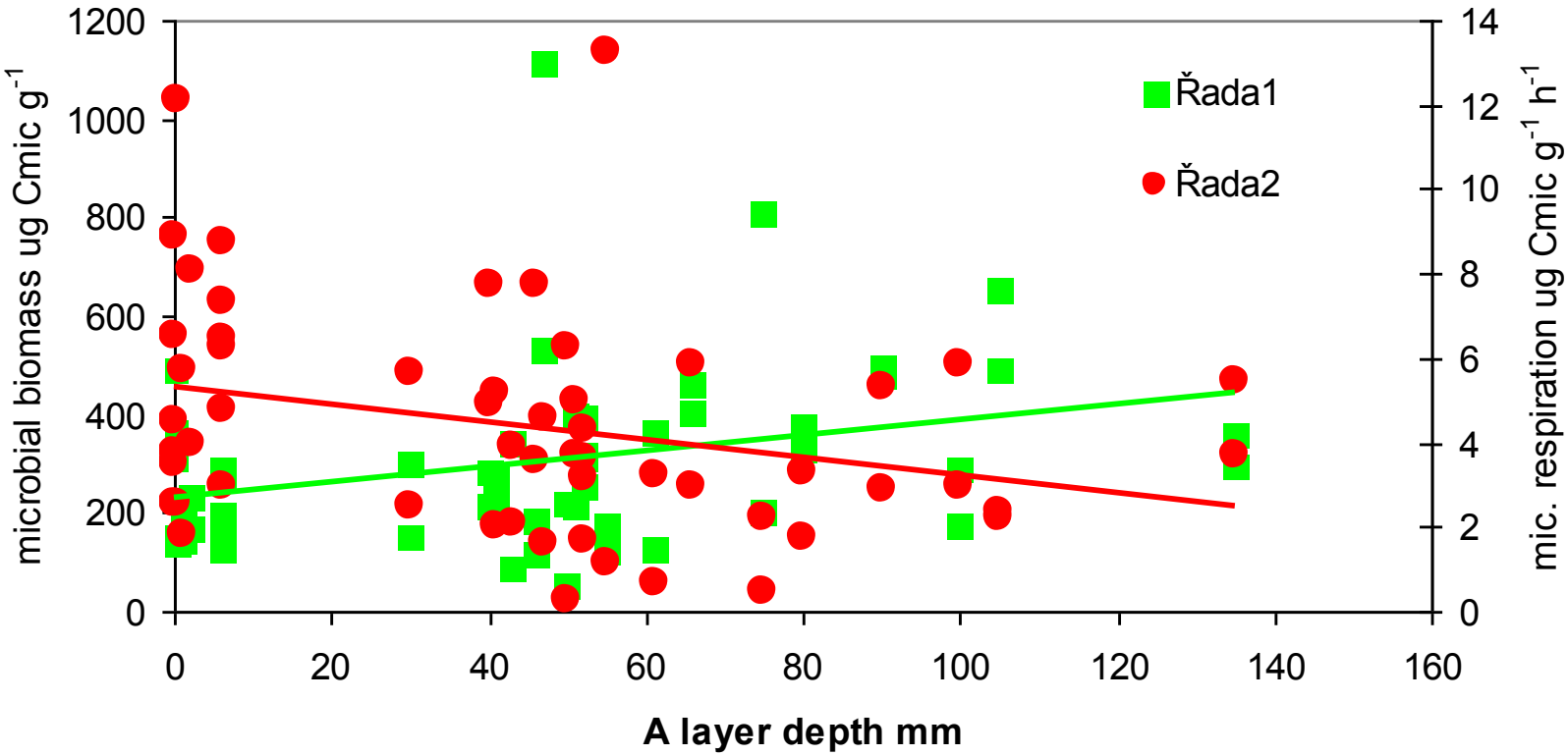


litter grounded

intact litter

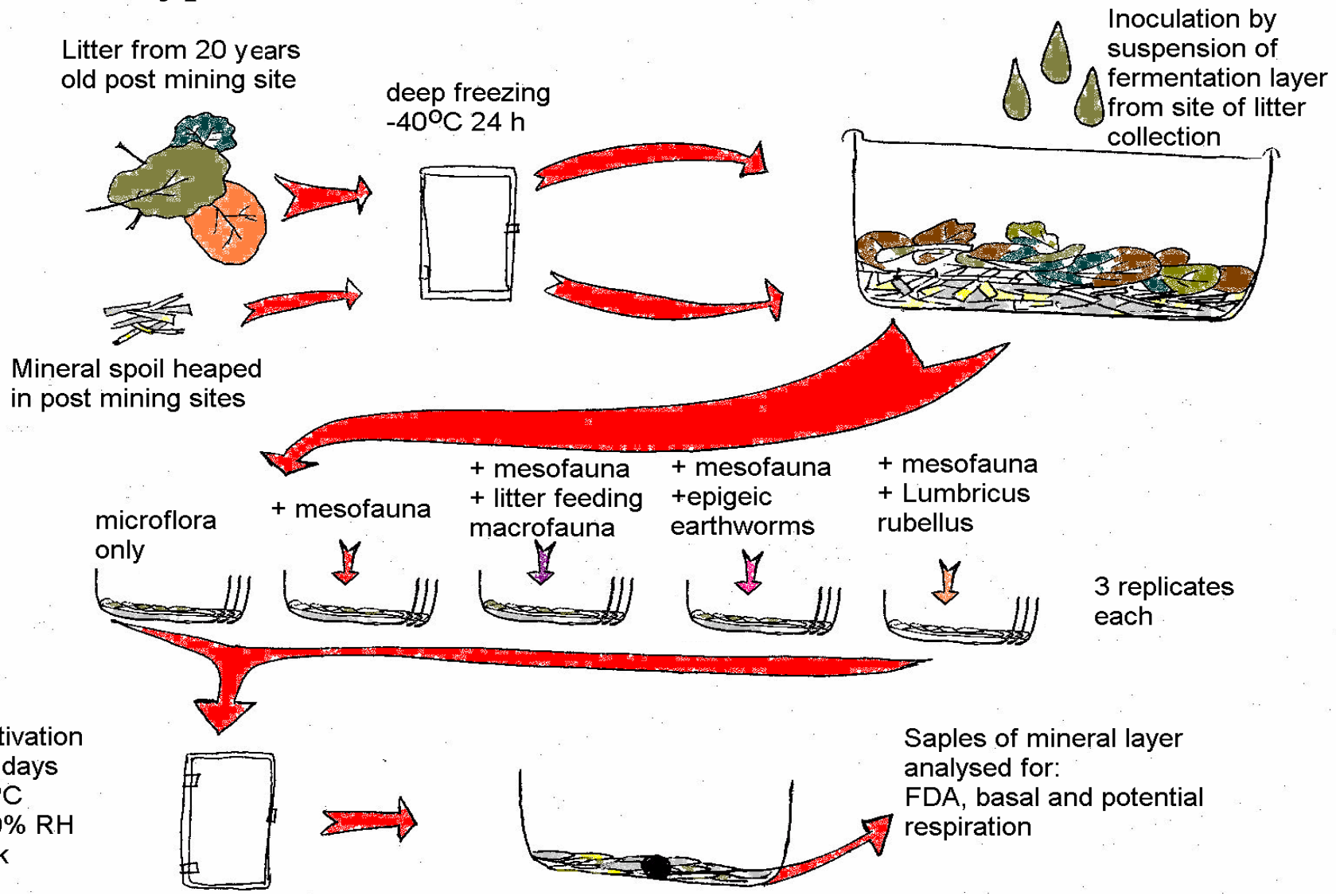
Priming effect is much bigger if liter is not mixed in soil



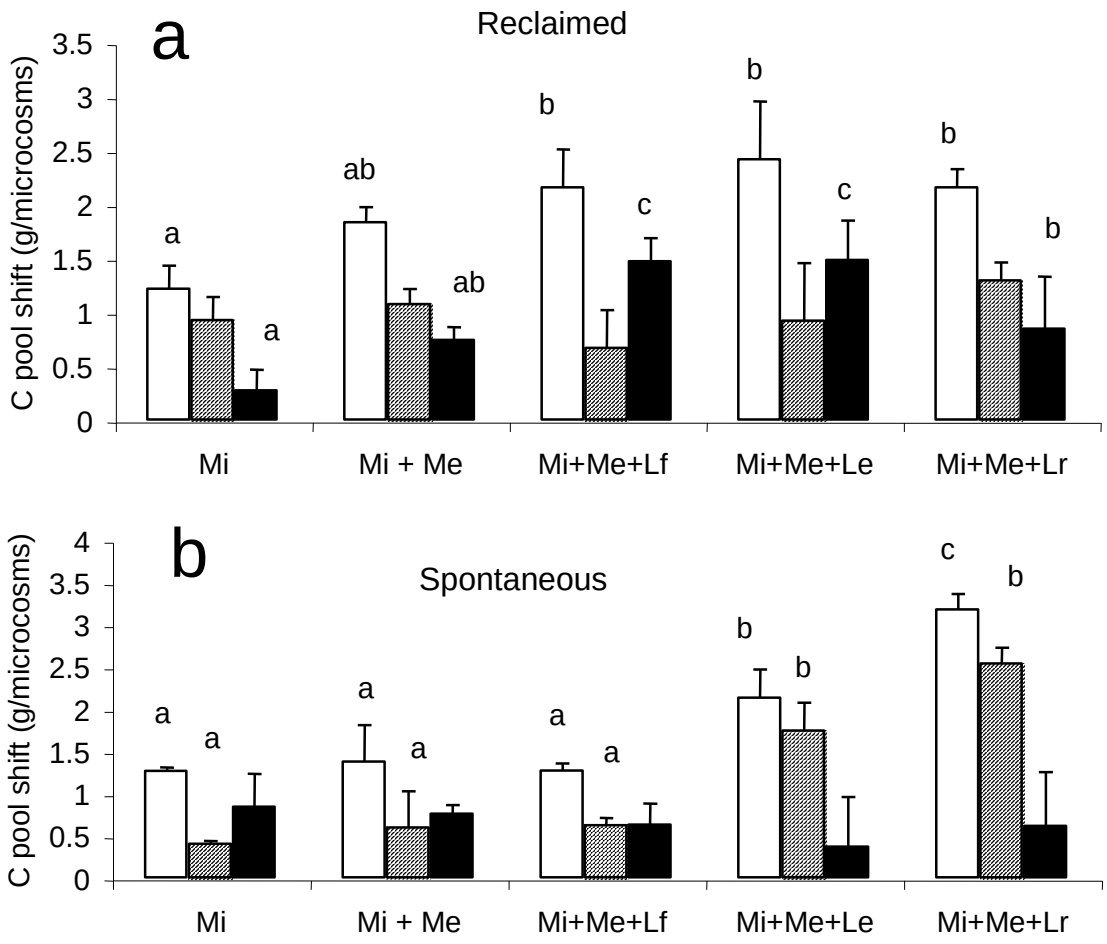


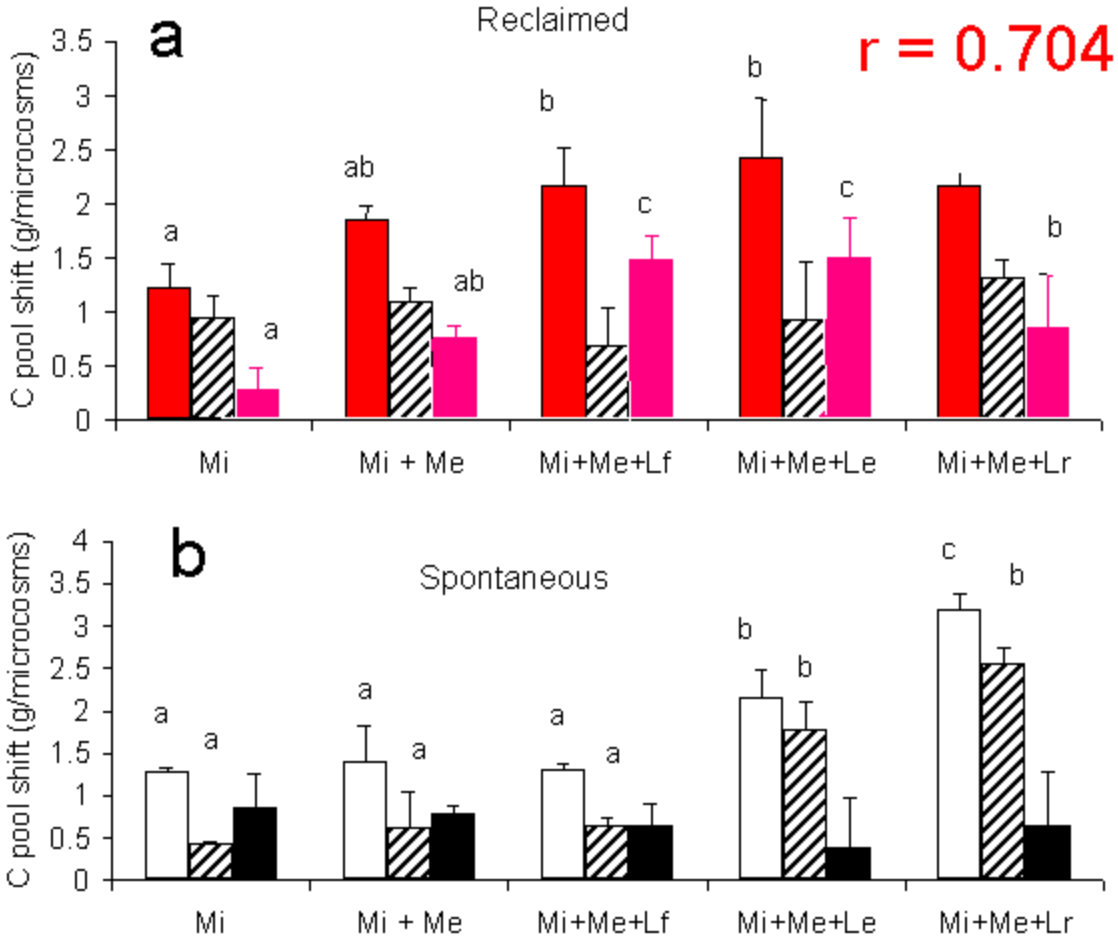
	biomass	respiration
pH KCl	-0.333	0.201
Cox	**0.601**	**-0.347**
tree cover	**0.271**	-0.177
F layer mm	**-0.398**	0.051
A layer mm	**0.317**	**-0.283**
worm cast	**0.445**	**-0.283**
earthworm dens.	**0.317**	-0.153
litter input	-0.153	0.041

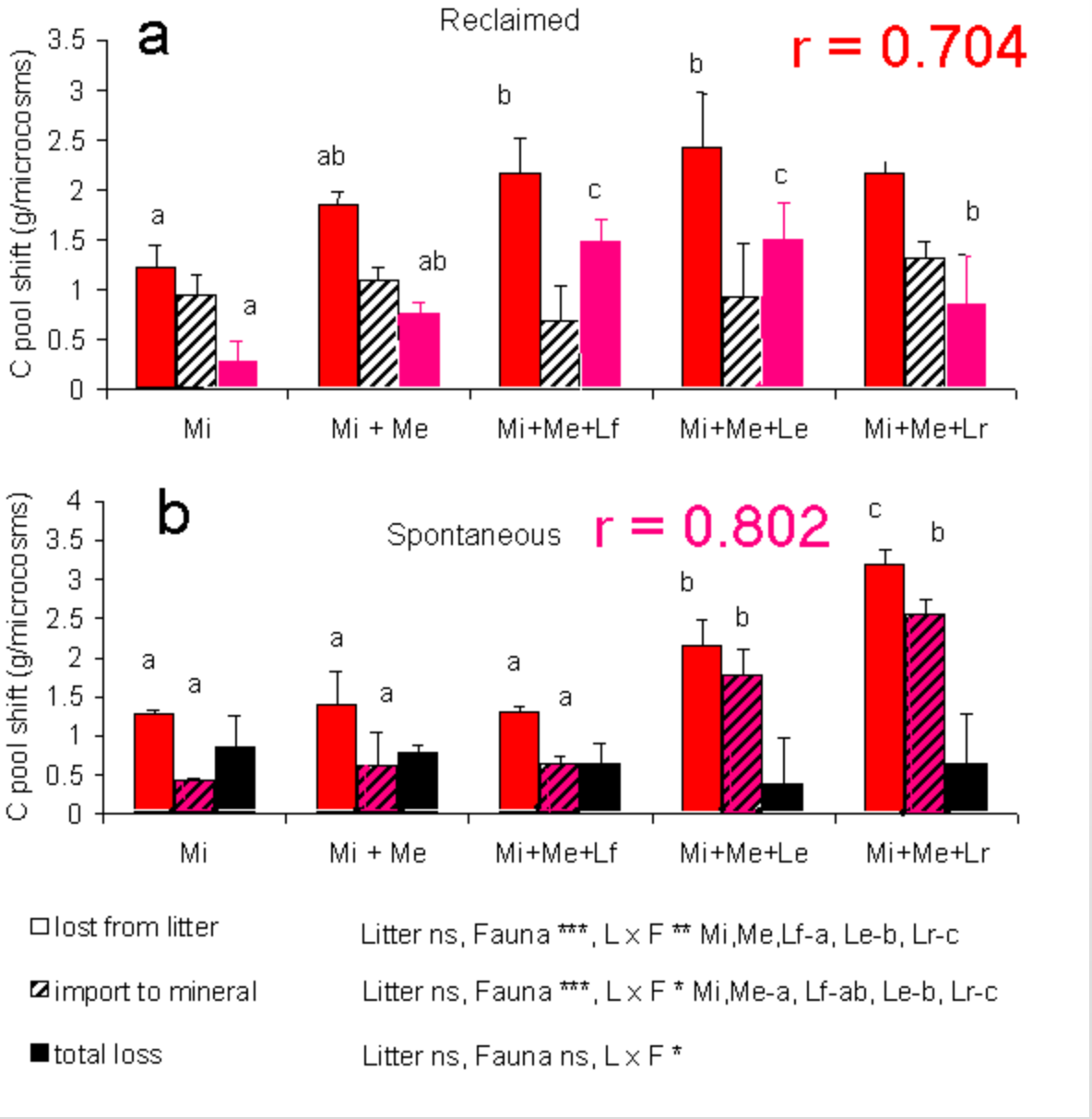
Two types: reclaimed unreclaimed

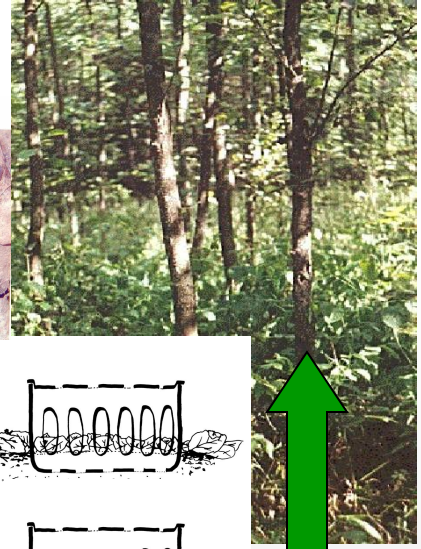


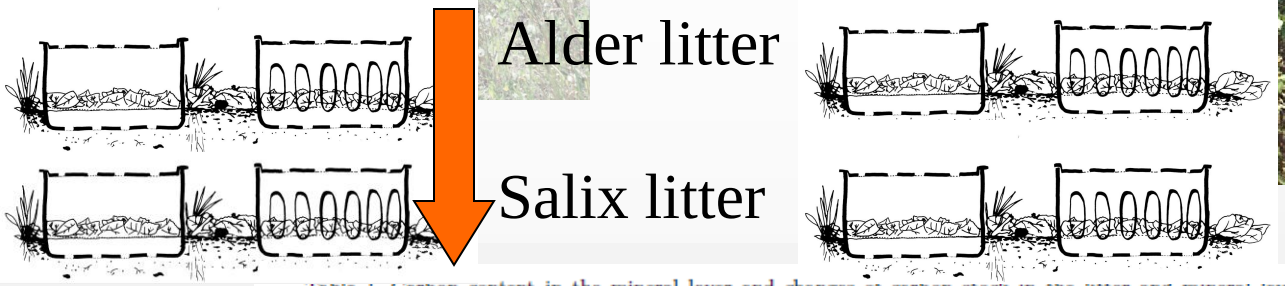
Scheme of experimental microcosms preparation and inoculation with various groups of soil fauna.


a
Reclaimed
C pool shift (g/microcosms)
3.5
3
2.5
2
1.5
1
0.5
0
a
ab
b
b
b
a
ab
c
c
b
a
b
Mi
Mi + Me
Mi+Me+Lf
Mi+Me+Le
Mi+Me+Lr
b
Spontaneous
C pool shift (g/microcosms)
4
3.5
3
2.5
2
1.5
1
0.5
0
a
a
a
a
a
a
b
b
c
b
Mi
Mi + Me
Mi+Me+Lf
Mi+Me+Le
Mi+Me+Lr
lost from litter
import to mineral
total loss
Litter ns, Fauna ***, L x F ** Mi,Me,Lf-a, Le-b, Lr-c
Litter ns, Fauna ***, L x F * Mi,Me-a, Lf-ab, Le-b, Lr-c
Litter ns, Fauna ns, L x F *


a
Reclaimed
r = 0.704
C pool shift (g/microcosms)
3.5
3
2.5
2
1.5
1
0.5
0
a
a
a
ab
ab
b
c
b
c
c
b
Mi
Mi + Me
Mi+Me+Lf
Mi+Me+Le
Mi+Me+Lr
b
Spontaneous
C pool shift (g/microcosms)
4
3.5
3
2.5
2
1.5
1
0.5
0
a
a
a
a
a
a
b
b
b
c
b
Mi
Mi + Me
Mi+Me+Lf
Mi+Me+Le
Mi+Me+Lr
lost from litter
import to mineral
total loss
Litter ns, Fauna ***, L × F ** Mi,Me,Lf-a, Le-b, Lr-c
Litter ns, Fauna ***, L × F * Mi,Me-a, Lf-ab, Le-b, Lr-c
Litter ns, Fauna ns, L × F *


a
Reclaimed
r = 0.704
C pool shift (g/microcosms)
3.5
3
2.5
2
1.5
1
0.5
0
a
ab
b
b
a
ab
c
c
a
b
Mi
Mi + Me
Mi+Me+Lf
Mi+Me+Le
Mi+Me+Lr
b
Spontaneous
r = 0.802
C pool shift (g/microcosms)
4
3.5
3
2.5
2
1.5
1
0.5
0
a
a
a
a
a
a
b
b
c
b
Mi
Mi + Me
Mi+Me+Lf
Mi+Me+Le
Mi+Me+Lr
lost from litter
import to mineral
total loss
Litter ns, Fauna ***, L × F ** Mi,Me,Lf-a, Le-b, Lr-c
Litter ns, Fauna ***, L × F * Mi,Me-a, Lf-ab, Le-b, Lr-c
Litter ns, Fauna ns, L × F *





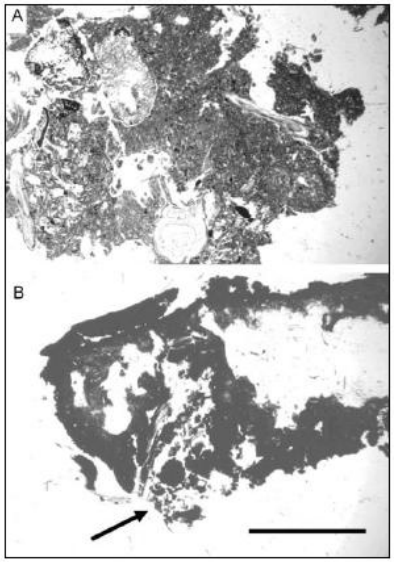


Fig. 2. Thin soil sections from the surface of the mineral layer of field microcosms that were exposed for one year. A – Treatment supplied with alder litter, exposed at the alder plantation and accessible for soil macro fauna; it was completely filled with earthworm cast. B – Treatment exposed in the spontaneous site and unaccessible to soil macrofauna. Enchytraeid and mesofauna excrements are marked by the arrow. Scale 1 mm.

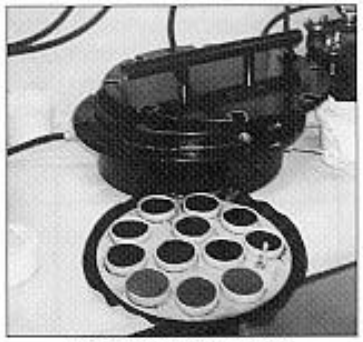
Table 1. Carbon content in the mineral layer and changes of carbon stock in the litter and mineral layers (mean ± SD) of field microcosms exposed for one year either in the alder plantation (A) or in sites covered by spontaneous succession (S) supplied either with alder litter or litter from a spontaneous site (the first letter marks the exposition site, the second letter marks the litter used in microcosms), which were either accessible (+) or non accessible (–) to soil macrocauna.

	C content in mineral layer (%)	C stock increase in mineral layer (g box^{-1})	C stock loss from litter layer (g box^{-1})	Total C loss (g box^{-1})
AA+	4.49 ± 0.98	0.47 ± 0.11*	6.83 ± 1.62	6.36 ± 1.67
AA-	3.16 ± 0.19	0.24 ± 0.04*	6.16 ± 1.34	5.92 ± 1.37
AS+	3.46 ± 0.10	0.30 ± 0.04	6.44 ± 0.39	6.15 ± 0.41
AS-	3.10 ± 0.47	0.23 ± 0.11	6.09 ± 0.60	5.86 ± 0.60
SA+	2.40 ± 0.36*	0.13 ± 0.10	7.27 ± 0.56	7.14 ± 0.46
SA-	3.24 ± 0.12*	0.24 ± 0.03	7.99 ± 0.26	7.75 ± 0.29
SS+	2.47 ± 0.21	0.09 ± 0.00*	4.34 ± 1.28	4.25 ± 1.28
SS-	2.11 ± 0.16	0.03 ± 0.02*	4.50 ± 0.52	4.47 ± 0.54

Three-way ANOVA	F	P	F	P	F	P	F	P
Site	19.68	**0.0005**	24.70	**0.0002**	0.53	0.4791	0.11	0.7399
Litter	5.76	**0.0299**	8.88	**0.0093**	12.56	**0.0029**	10.65	**0.0052**
Macrofauna	1.78	0.2024	2.59	0.1281	0.01	0.9425	0.00	0.9609
Site x litter	0.00	0.9710	0.16	0.6908	9.45	**0.0077**	8.97	**0.0091**
Site x macrofauna	5.79	**0.0294**	5.67	**0.0310**	0.96	0.3418	0.62	0.4441
Litter x macrofauna	0.07	0.7934	0.01	0.9371	0.02	0.9031	0.01	0.9093
All factors Interaction	5.86	**0.0286**	4.95	**0.0419**	0.20	0.6600	0.07	0.7883

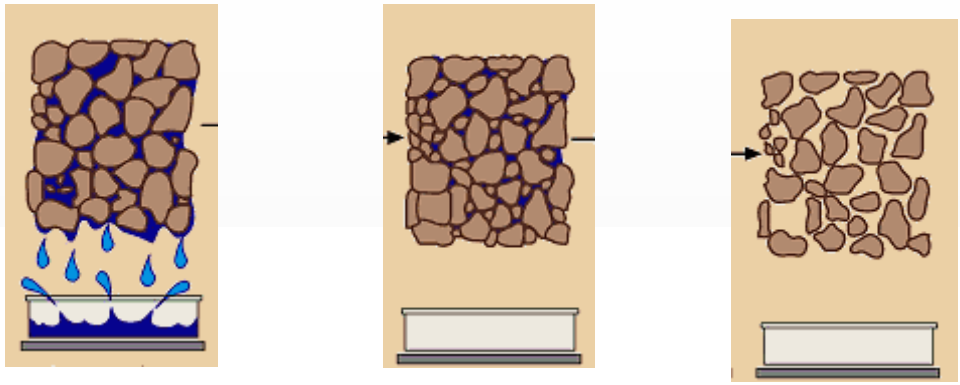
Explanations: * Indicates a significant difference between fauna accessible and non accessible treatment (t- test, $P < 0.05$). The bottom of the table summarises F (the first column for each parameter) and P (the second column) values of three-way ANOVA for individual factors and their interactions, $n = 24$.

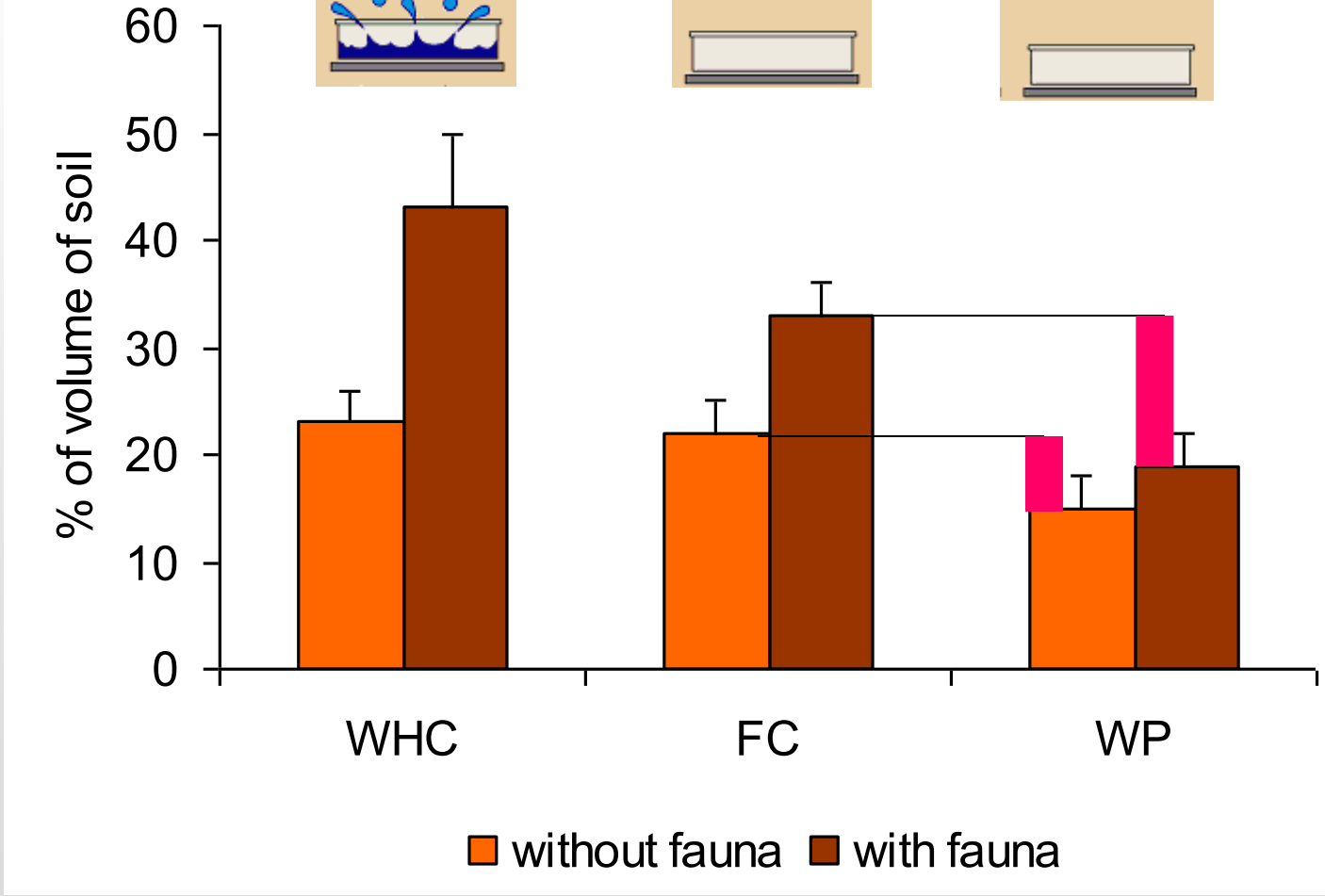
Effect of SOM accumulation on soil water budget



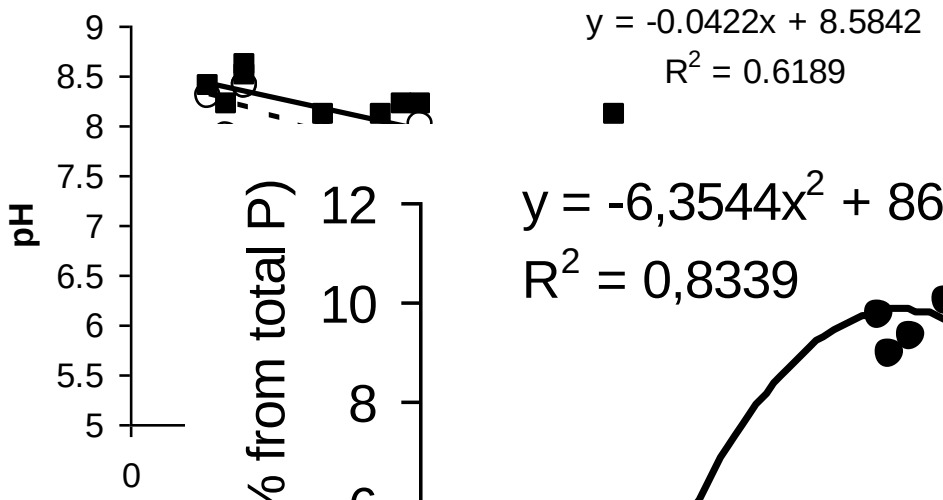
15 Bar laboratory apparatus

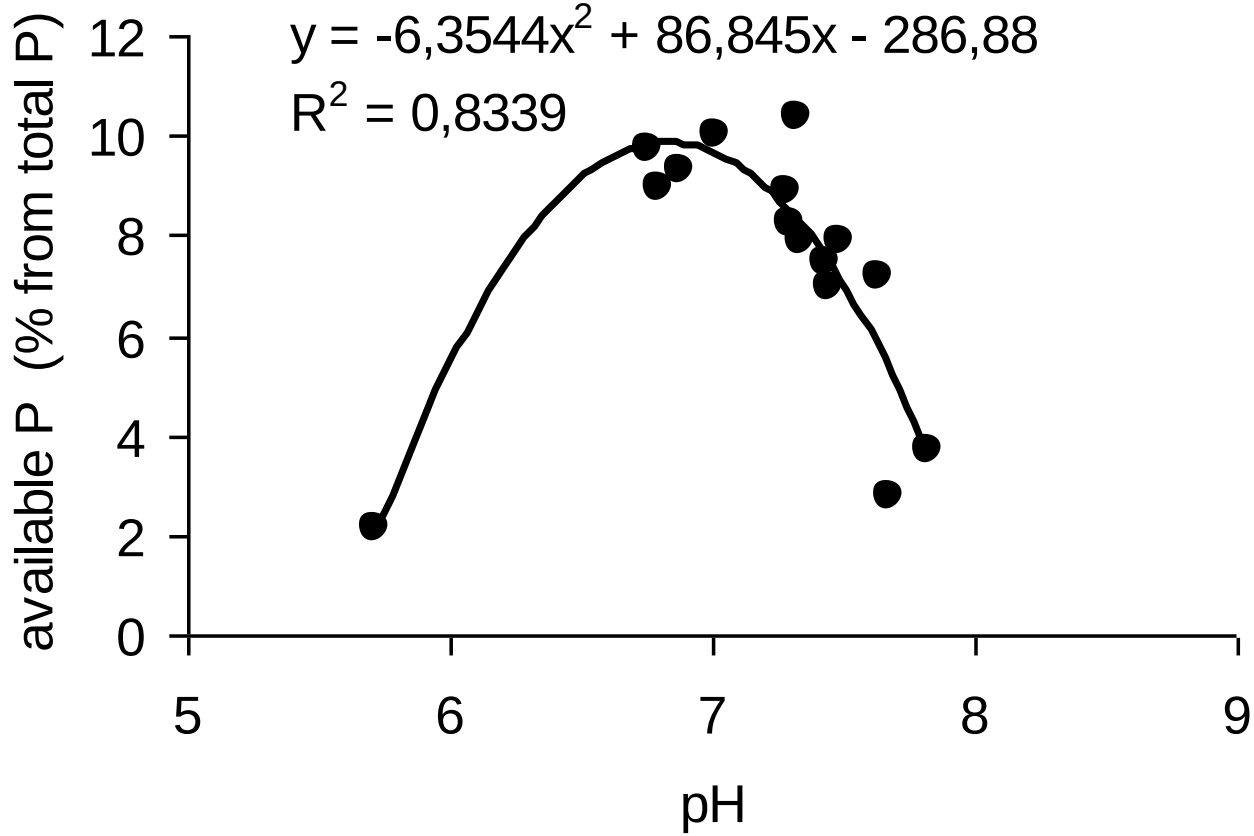
1/3 (.333) Bar laboratory apparatus

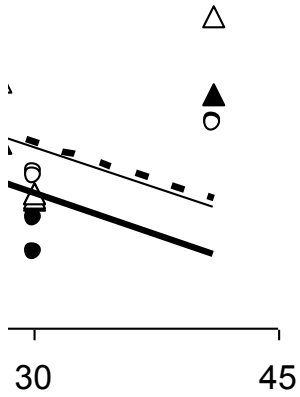




Effect of SOM accumulation on soil chemical properties

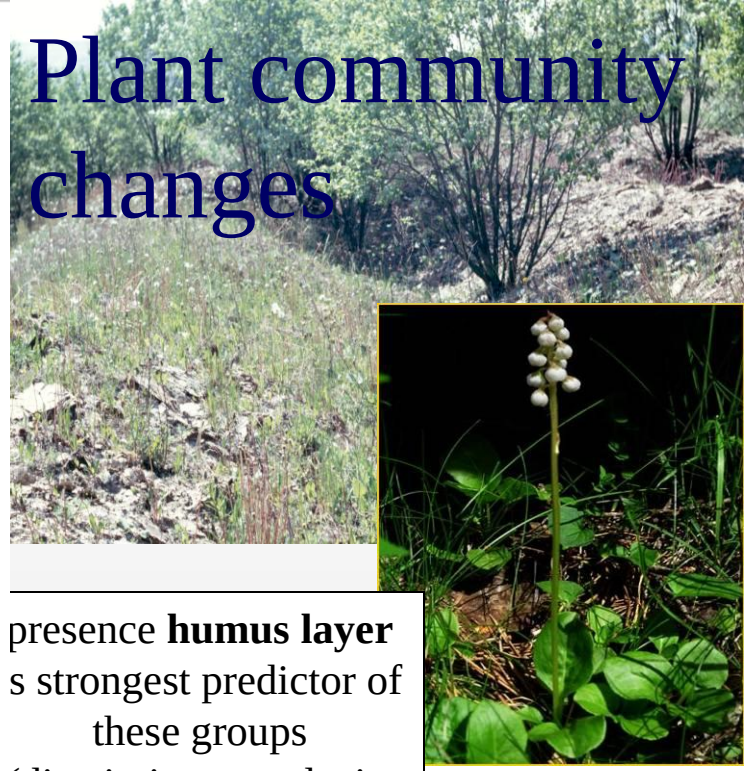


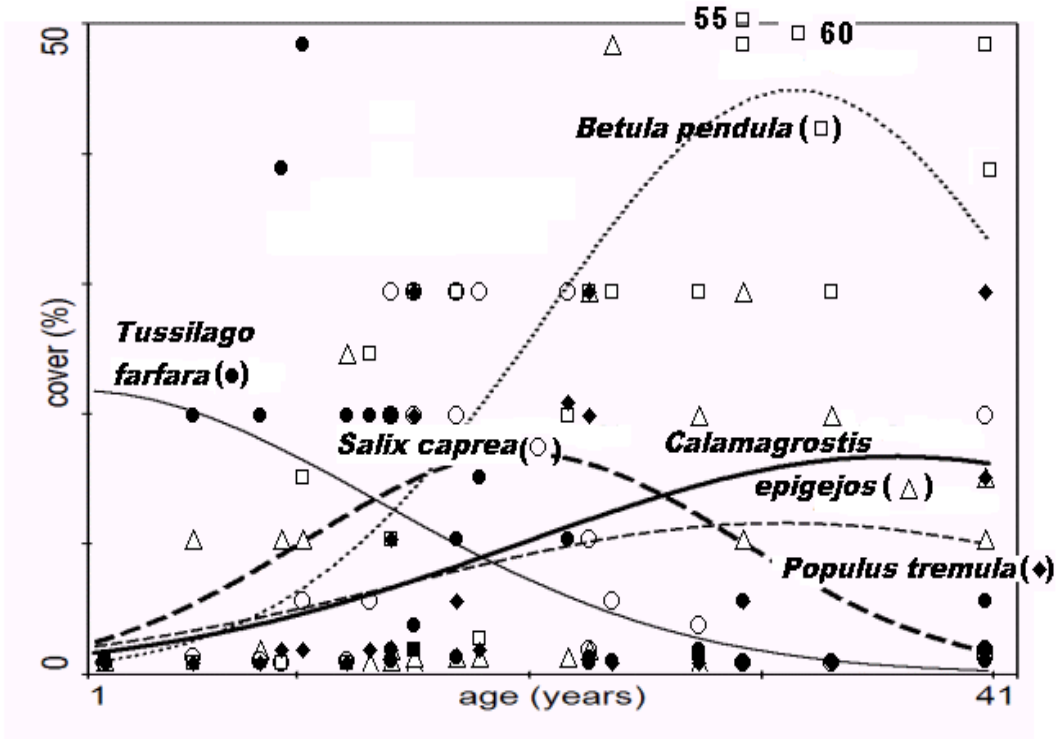




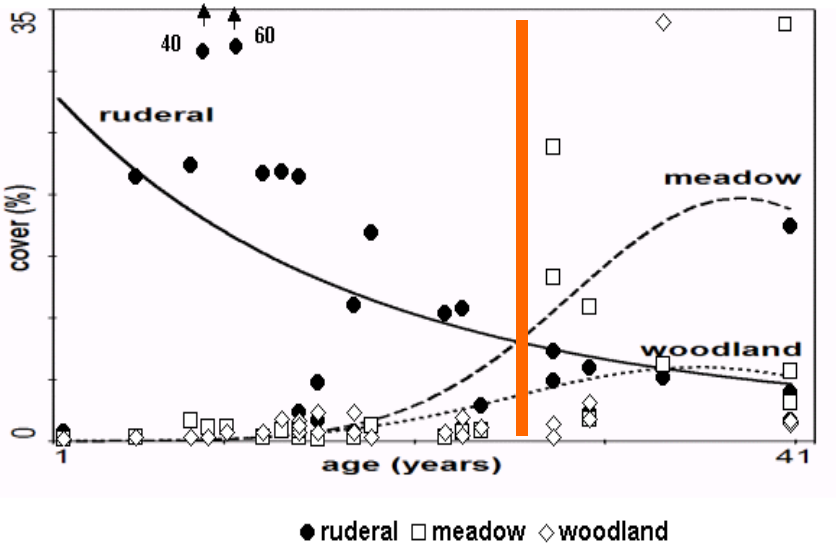
● 0-5 D; y = -0.0517x + 7.8115; R = 0.637
○ 0-5 E; y = -0.0506x + 8.2123; R = 0.800
▲ 5-10D; y = -0.0482x + 8.1898; R = 0.735
△ 5-10 E

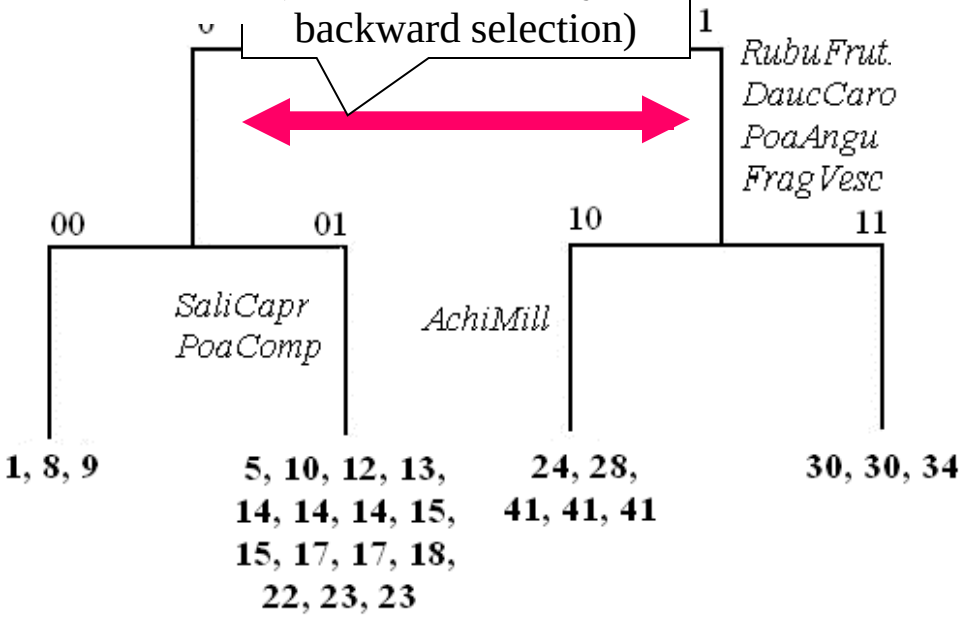
Plant community changes





presence **humus layer** s strongest predictor of these groups (discriminant analysis, backward selection)

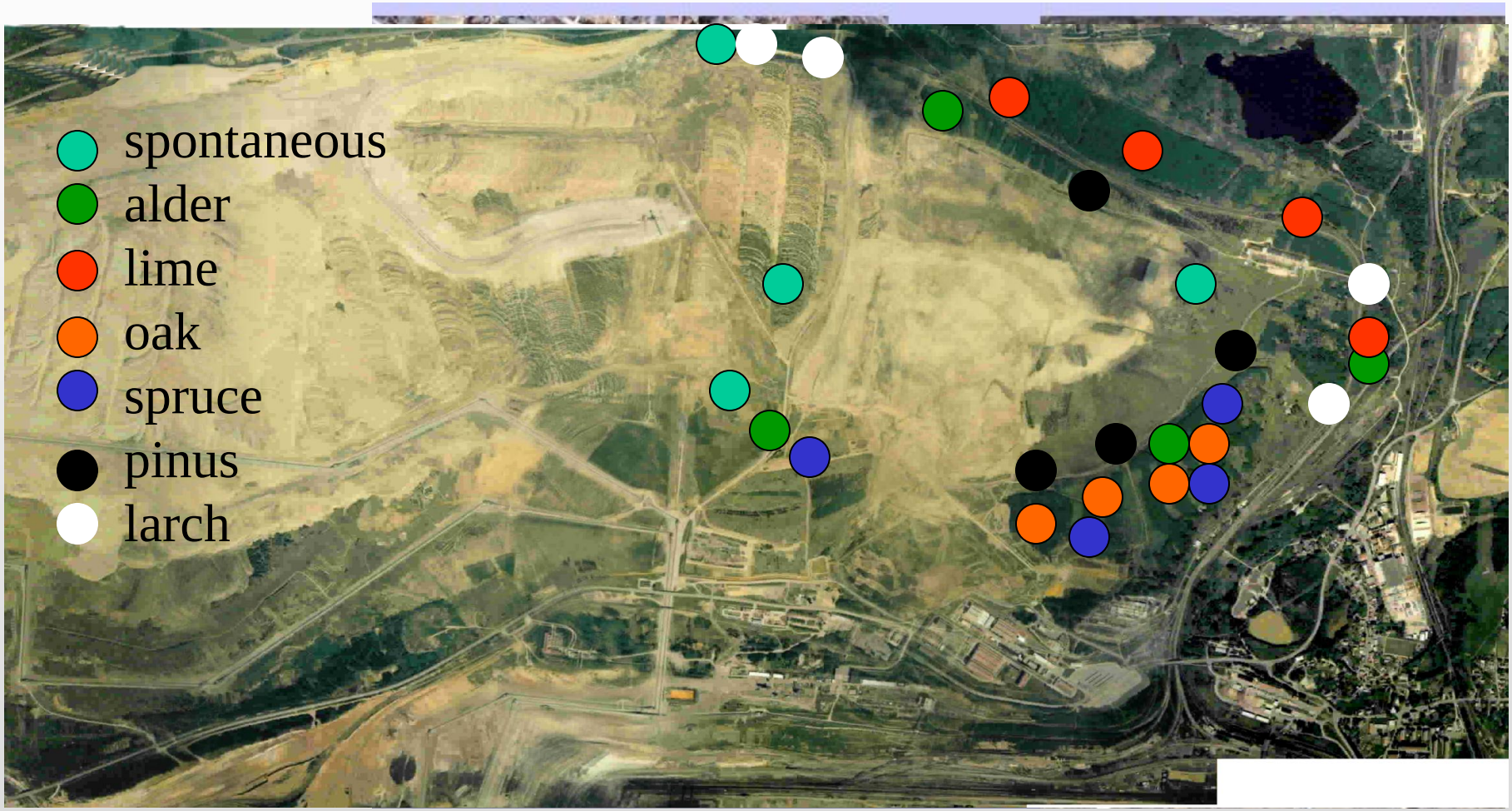


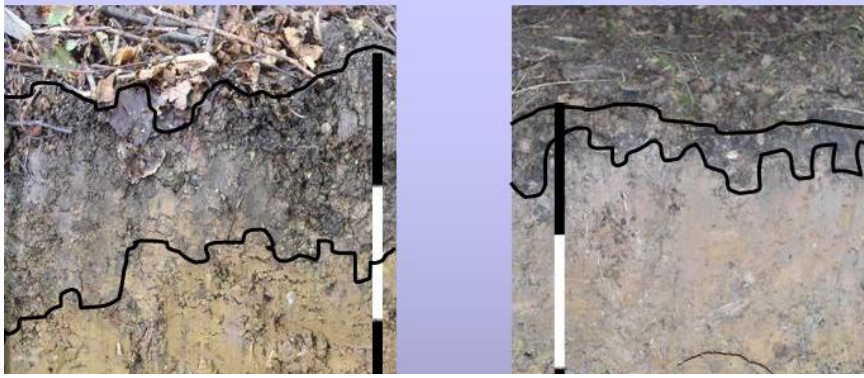


How we can use remote snesing in soil studies

a) study soil profile or samples in the lab

b) study of soil on landscape level (from plane, satelite etc)





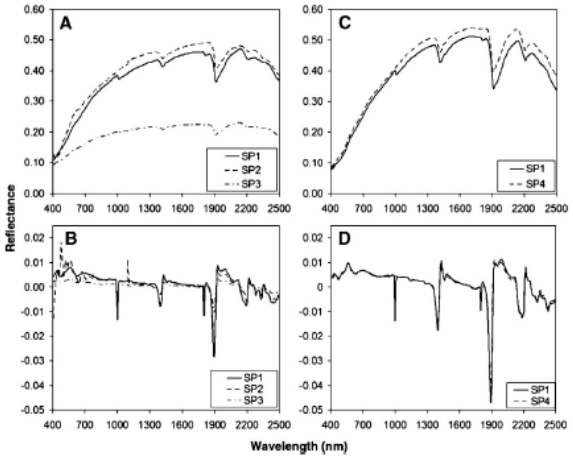


Fig. 1. Mean reflectance and the first derivative spectra of the Quemado sample set (A and B) and mean reflectance and the first derivative spectra of the Central Texas sample set (C and D) scanned by different spectrometers. SP1 is ASD AgriSpec; SP2 is Foss NIRSystems 6500; SP3 is ASD LabSpec 5000; and SP4 is ASD FieldSpec Pro.

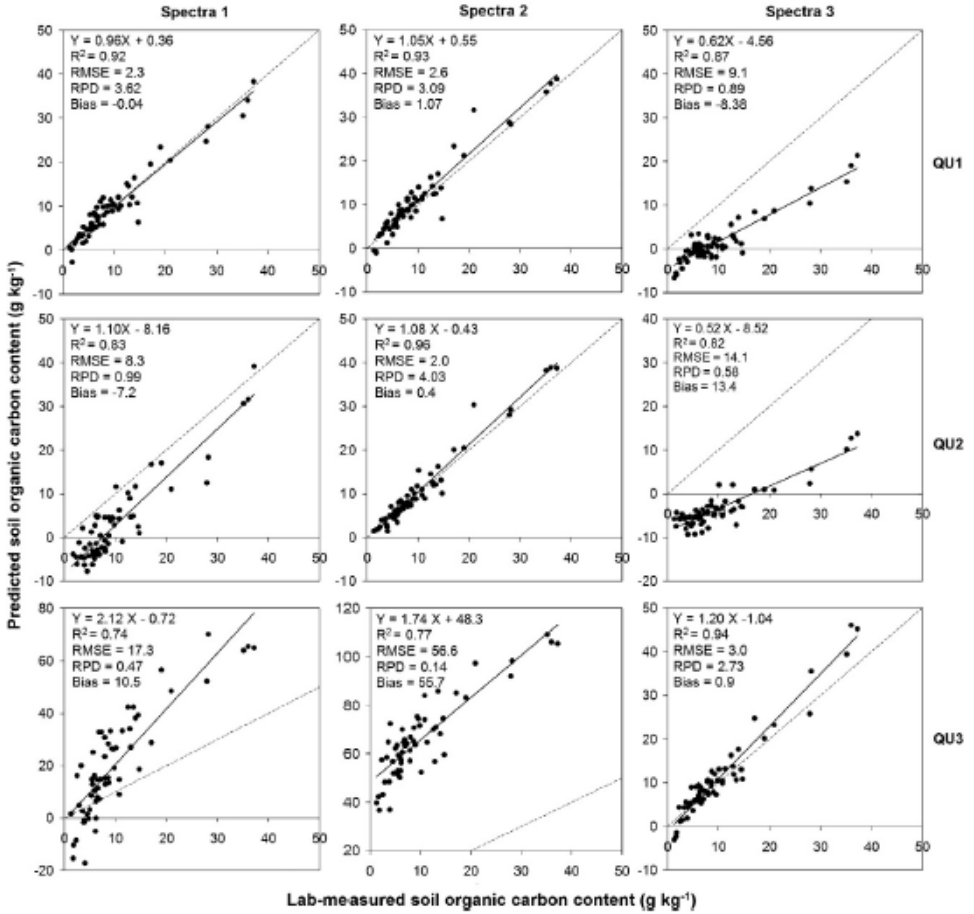
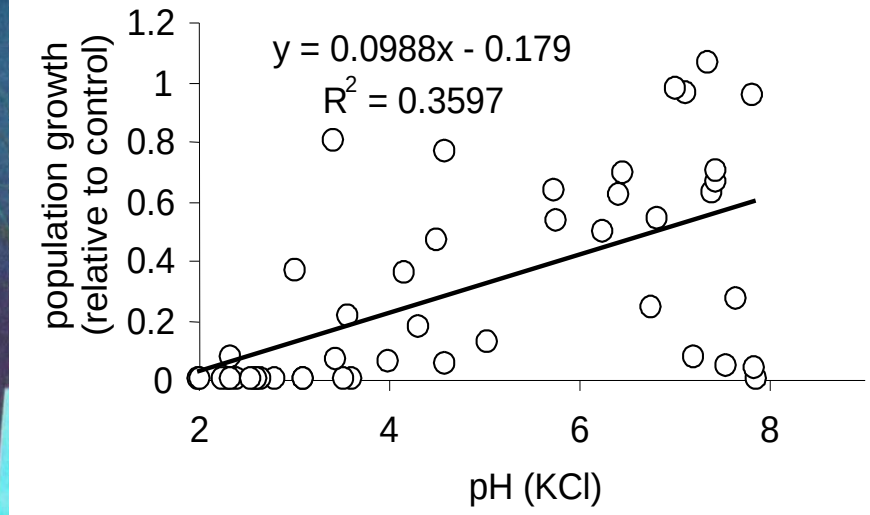
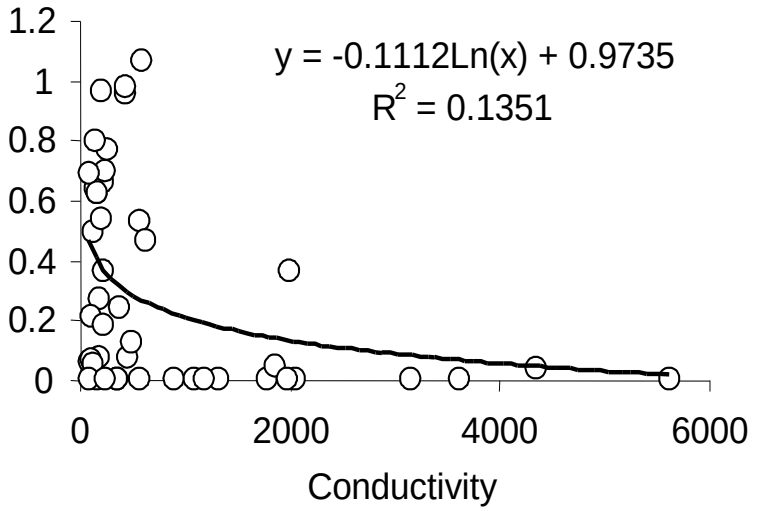
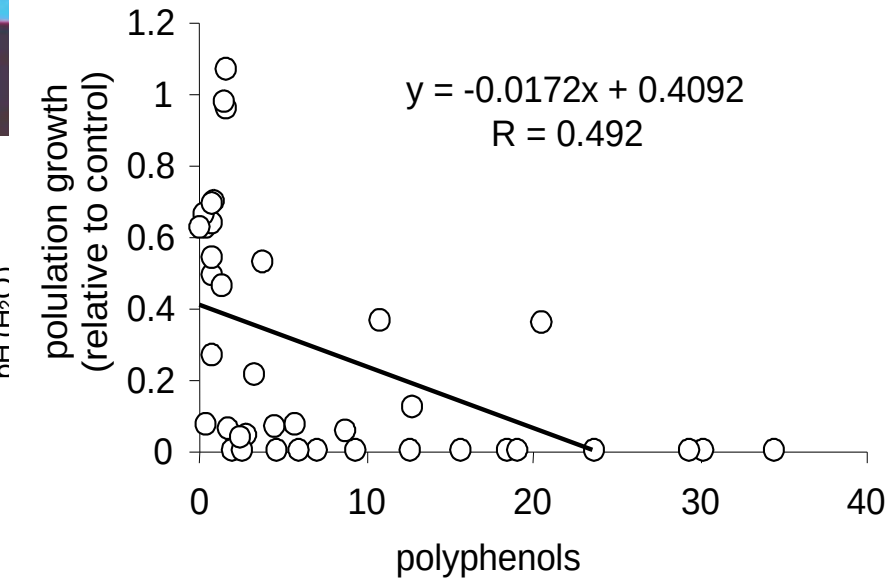


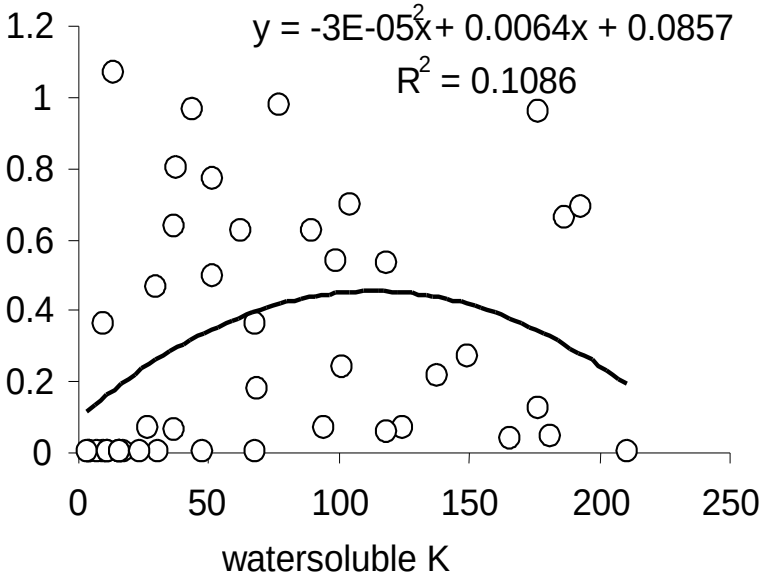
Fig. 5. Lab-measured versus VNIR-DRS predicted soil organic carbon content for the validation set (n = 60) in the Quemado sample set. The validation was done by applying each calibration model to validation spectra by different spectrometers. Models QU1, QU2, and QU3 are calibrated on SP1, SP2, and SP3, respectively, and validation spectra 1, 2, and 3 are measured by SP1, SP2, and SP3, respectively.

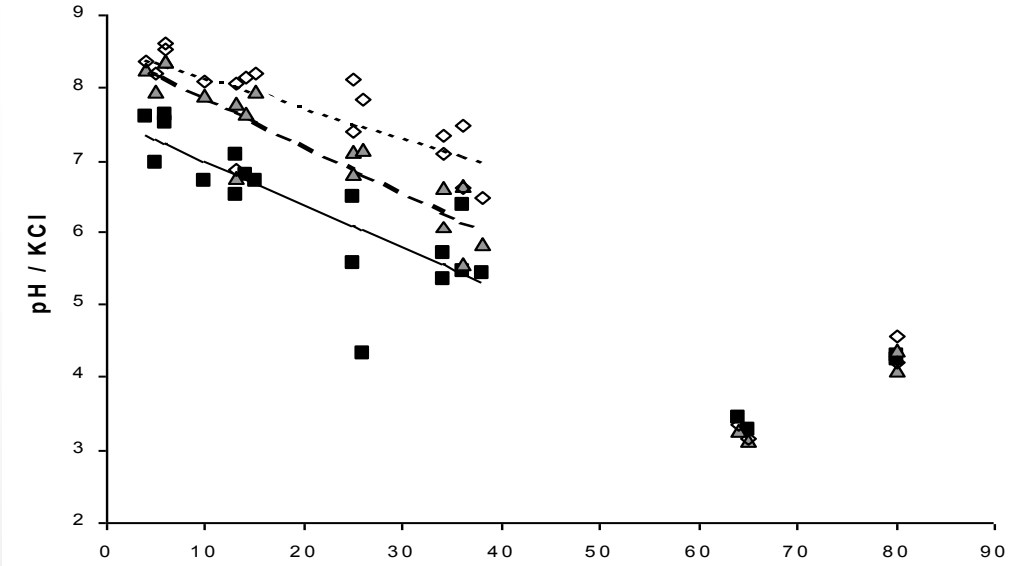
What are the possibilities for remote sensing?

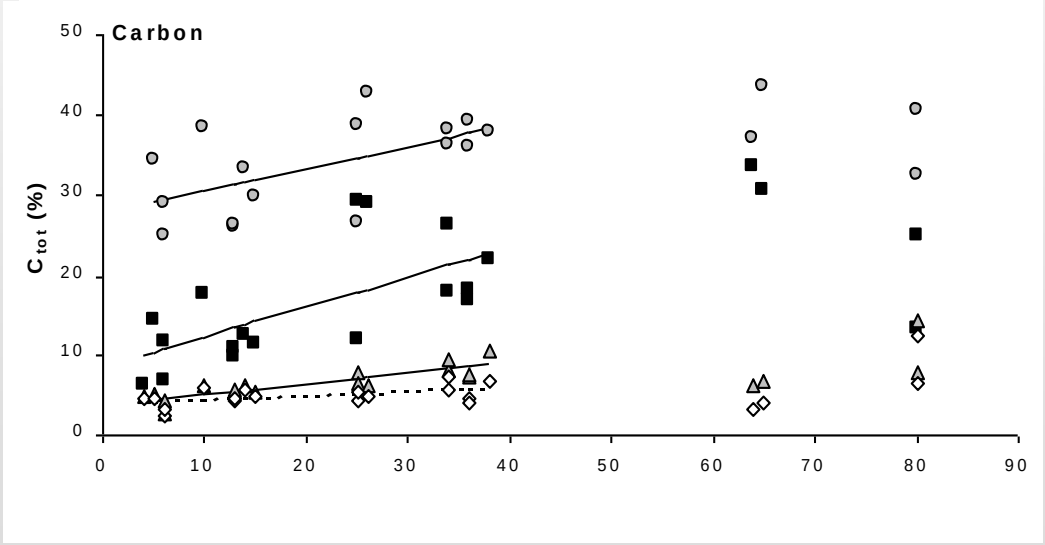

population growth (relative to control)
y = 0.0988x - 0.179
R2 = 0.3597
1.2
1
0.8
0.6
0.4
0.2
0
2
4
6
8
pH (KCl)

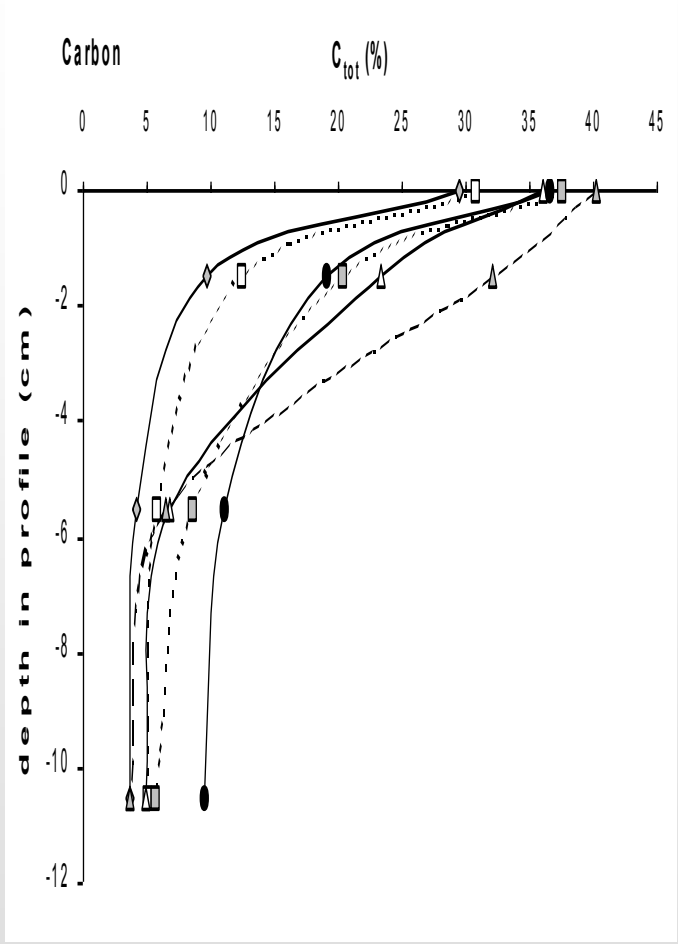

y = -0.1112Ln(x) + 0.9735
R2 = 0.1351
1.2
1
0.8
0.6
0.4
0.2
0
0
2000
4000
6000
Conductivity

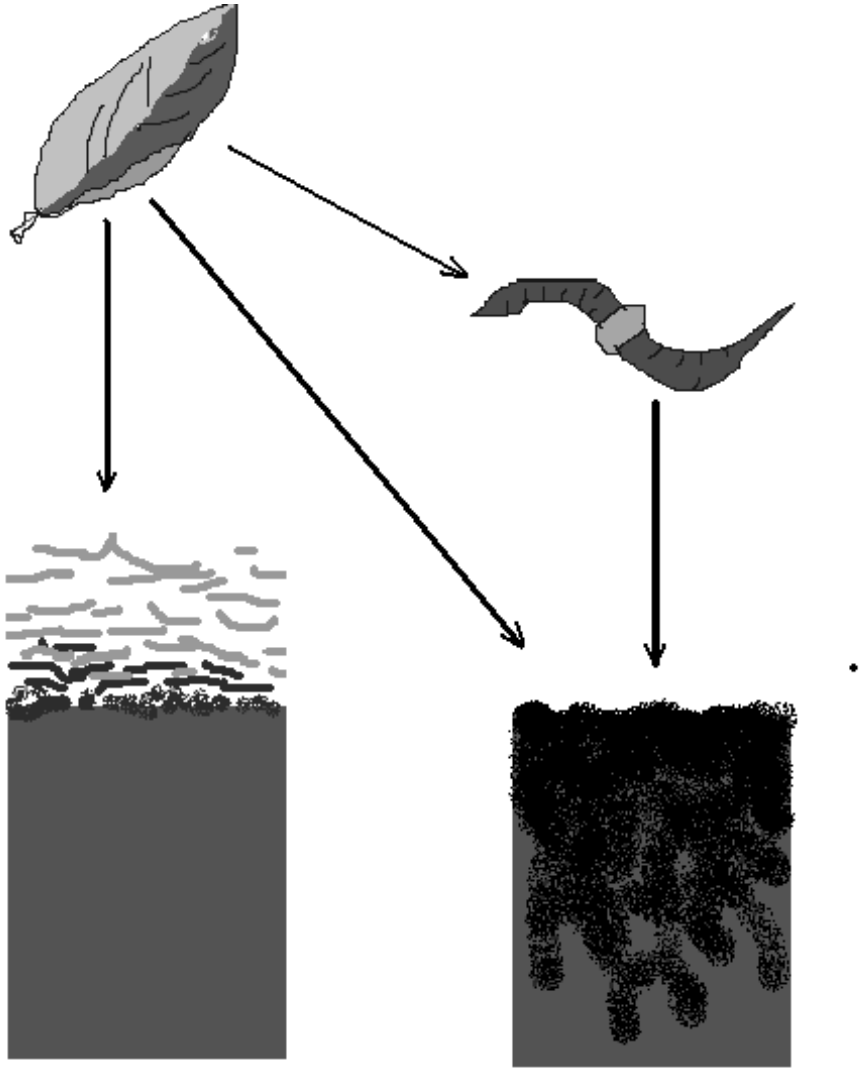

population growth (relative to control)
y = -0.0172x + 0.4092
R = 0.492
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
40
polyphenols


y = -3E-05x2 + 0.0064x + 0.0857
R2 = 0.1086
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
watersoluble K


pH / KCl
9
8
7
6
5
4
3
2
0
10
20
30
40
50
60
70
80
90


Carbon
C_{tot} (%)
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90

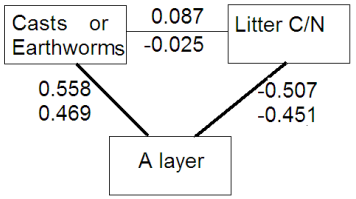

Carbon
C_{tot} (%)
0
5
10
15
20
25
30
35
40
45
depth in profile (cm)
0
-2
-4
-6
-8
-10
-12

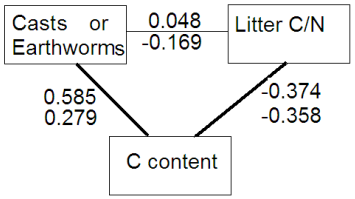


microbial respiration

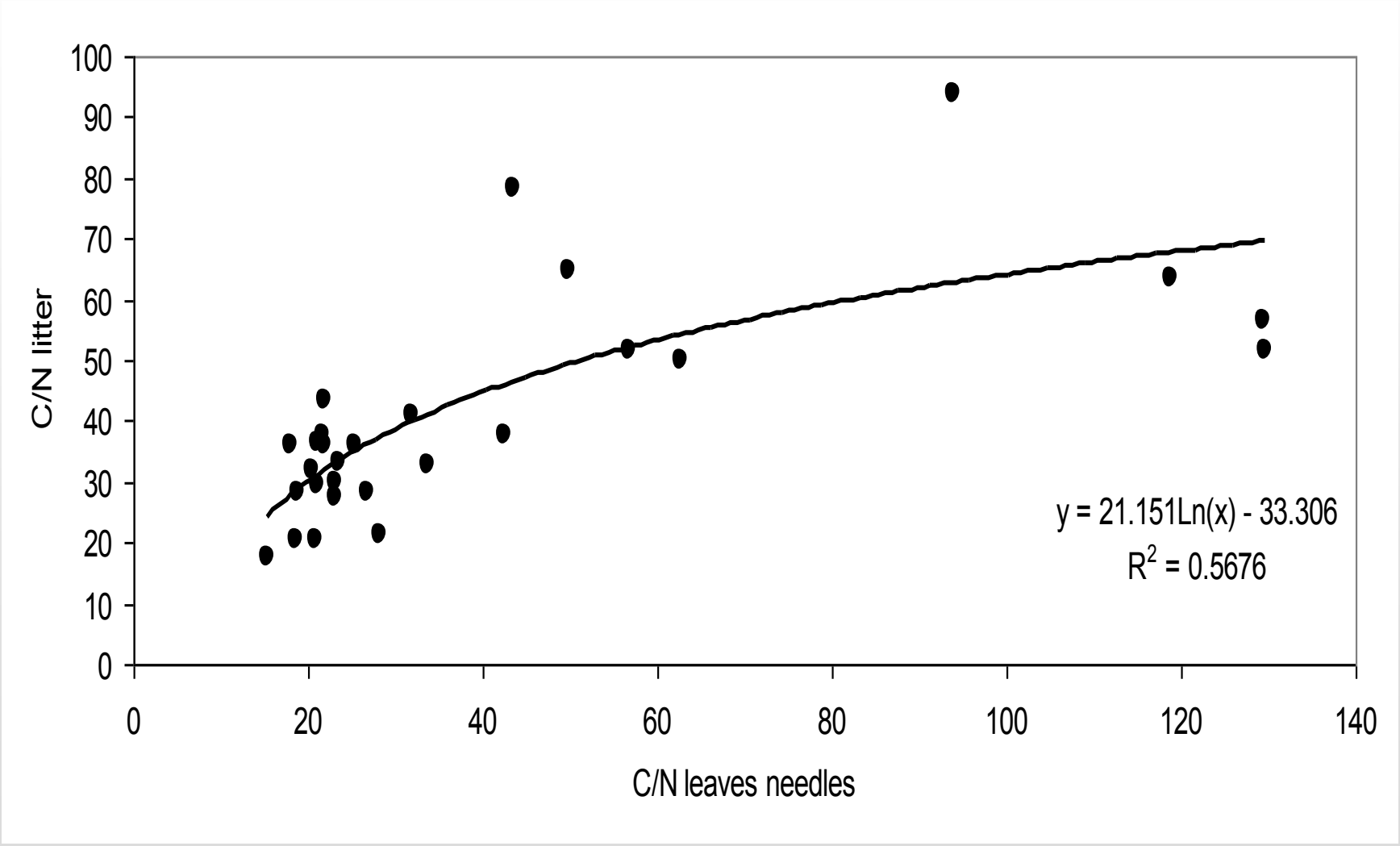
microbial biomass

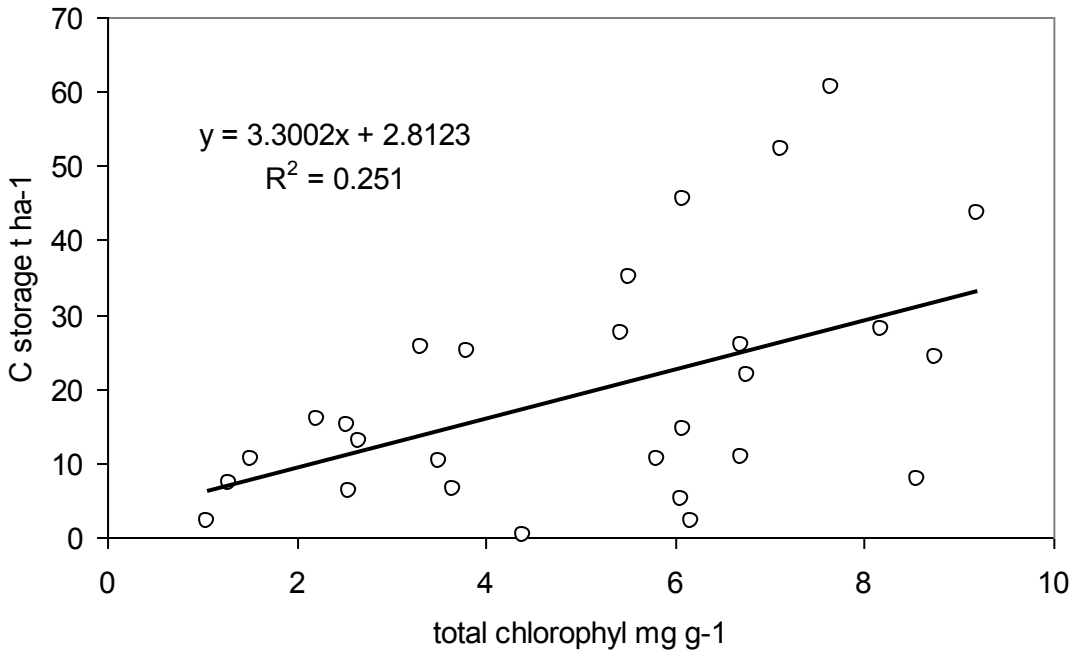
C storage

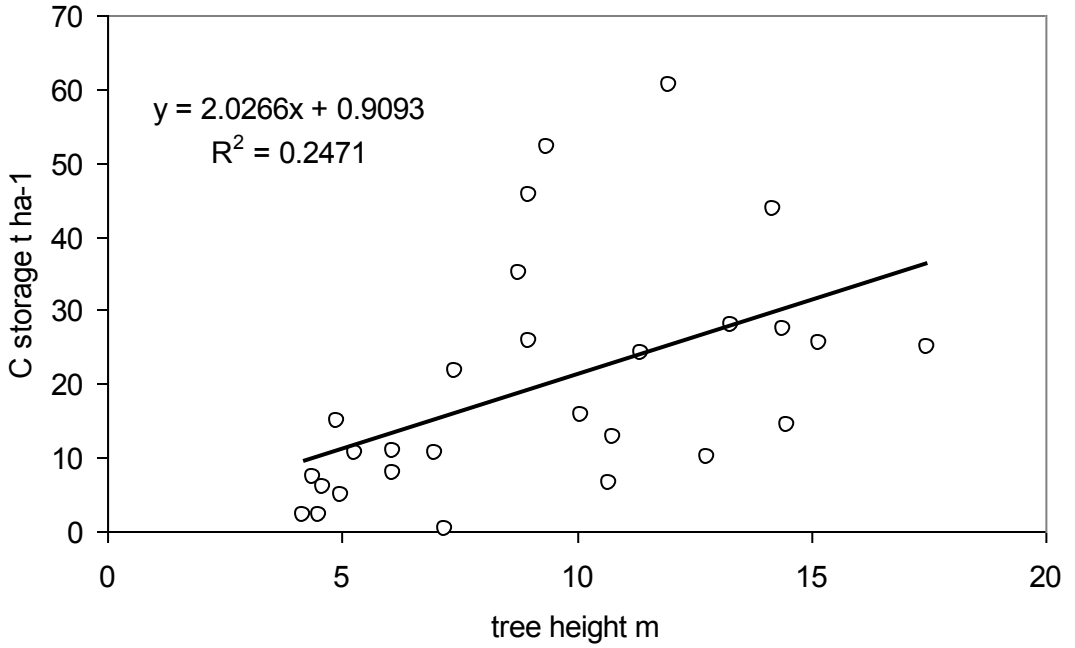




Litter quality correspond with foliage



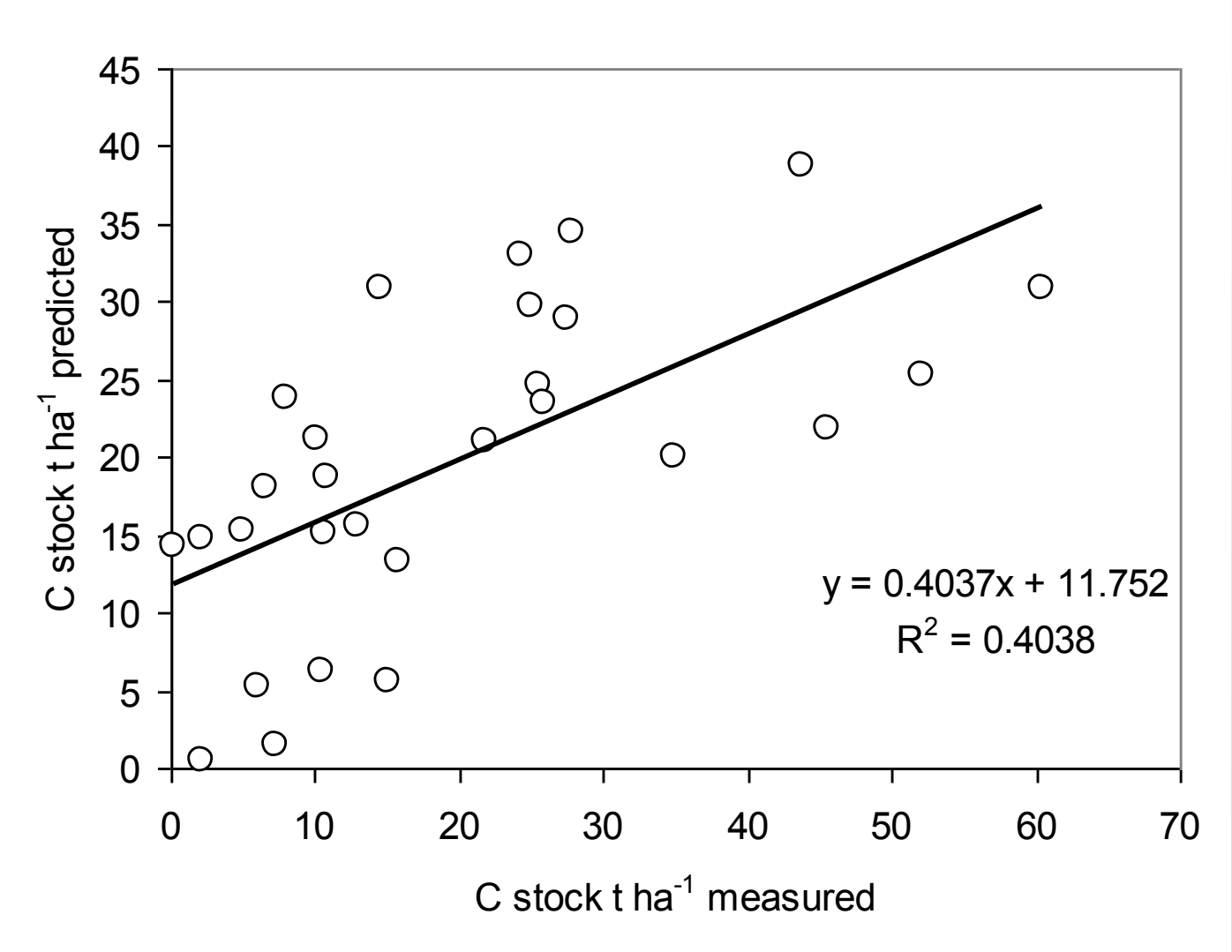




Both chlorophyll content
and tree height give significant correlation with C storage in soil.

Tree height and chlorophyll are not correlated

C stock=-9.2256+(2.681*chlorophyll content) +(1.6388*tree height)



Thank you for your attention

Sponzors

GA ČR 526/01/1055, 526/03/1259 a 526/06/0728

AV ČR S600220501

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Sokolovská Uhelná