Soils, vegetation, carbon sequestration in spoil heaps after brown coal mining

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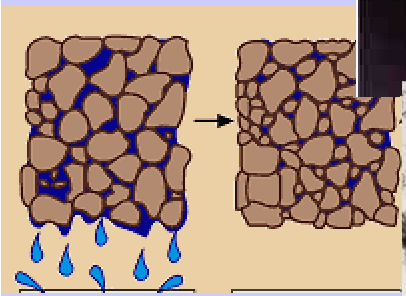
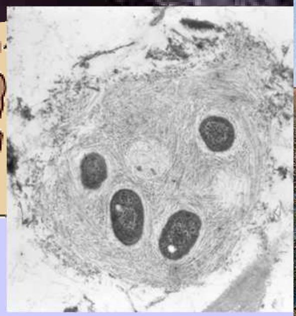
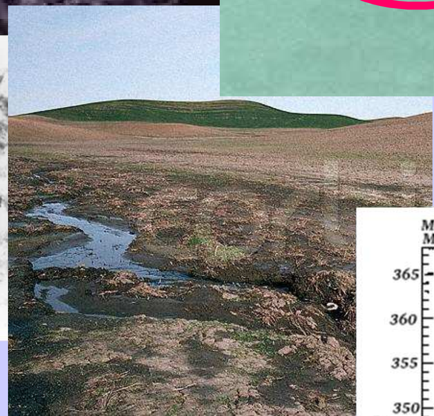
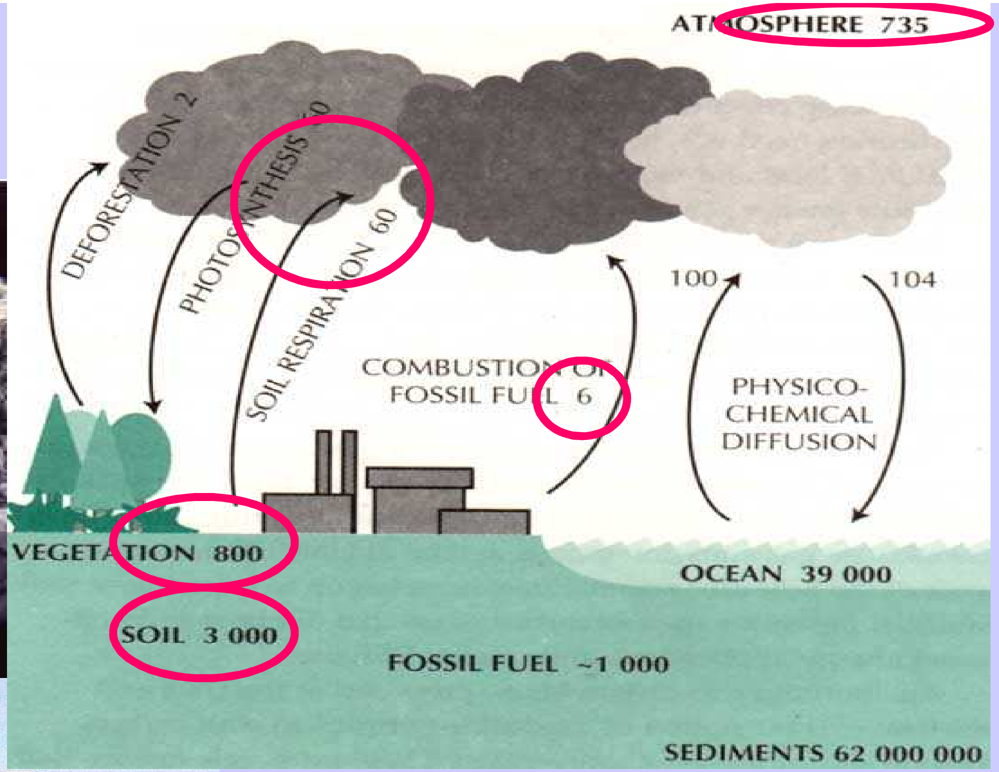
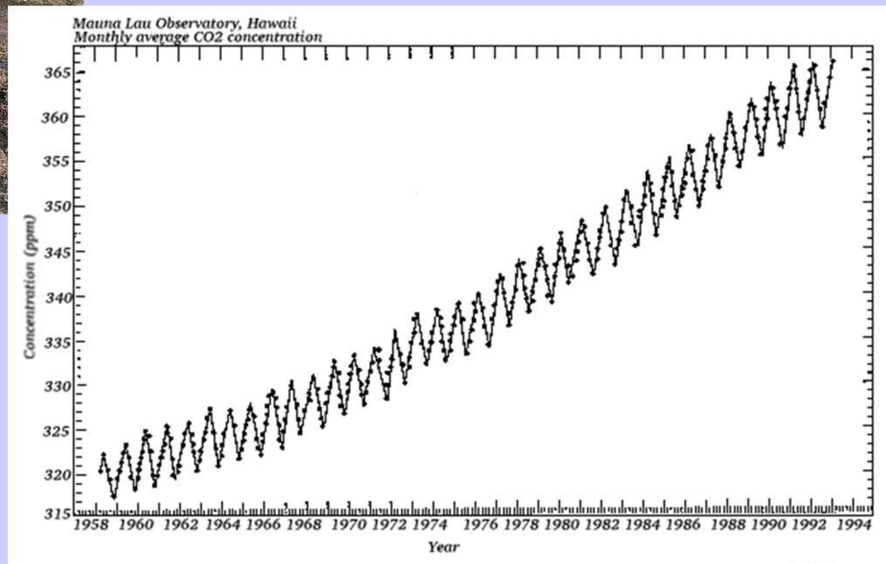
Why soil carbon ?











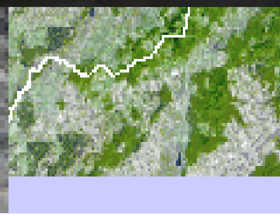
Main questions:

What is overall carbon storage in various reclaimed and non reclaimed post mining site.

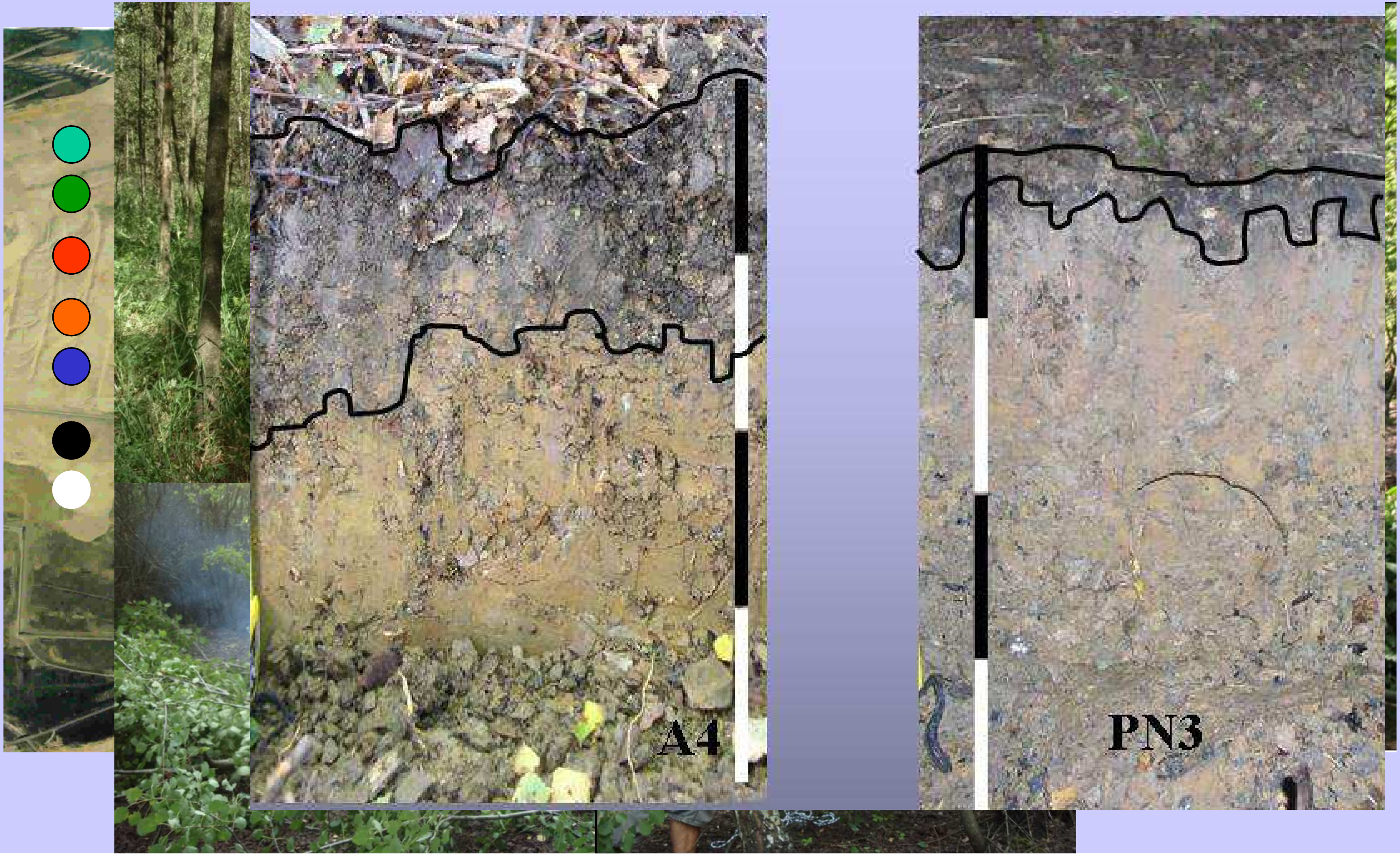
1) **How is the distribution of SOM in in soil profile in these sites**
2) **How the soil biota and litter quality affect SOM distribution in soil profile**
3) **How C distribution in soil profile effect other ecosystem function (microbial activity, soil physic etc.)**
4) **What remote sensing can bring to study soil vegetation relationship in disturbed sites**

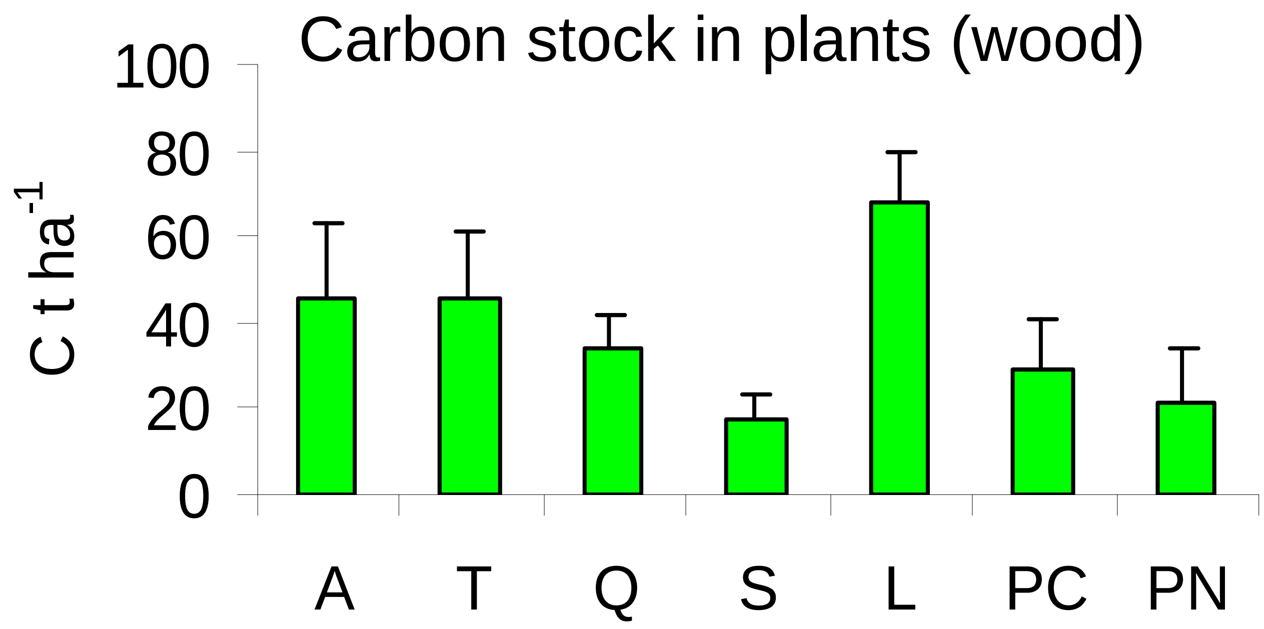
Chronosequences of reclaimed and unreclaimed plots in Sokolov coal mining district.

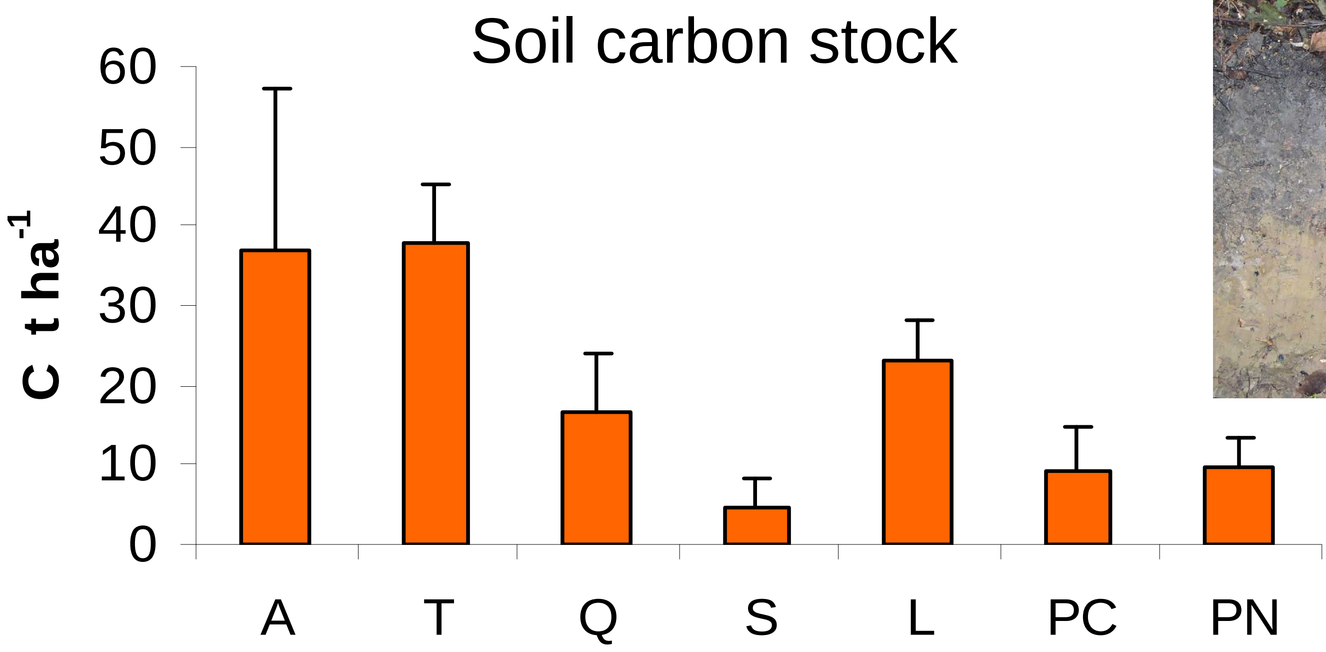
Tailings are formed by tertiary alkaline clay sediment (pH 8).



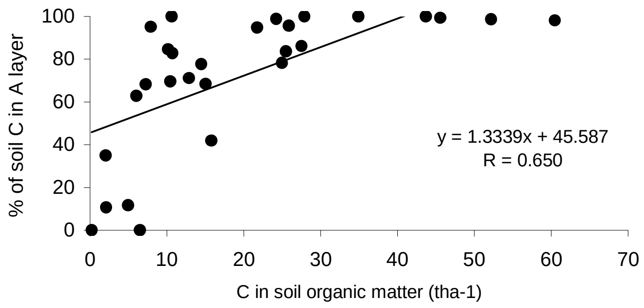
Comparison of soil development under various plantations.





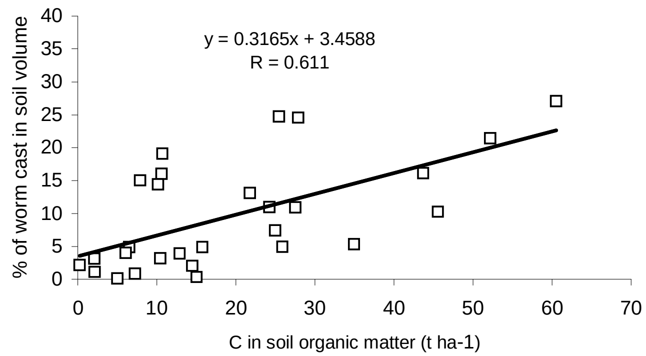


22-32
year
old sites

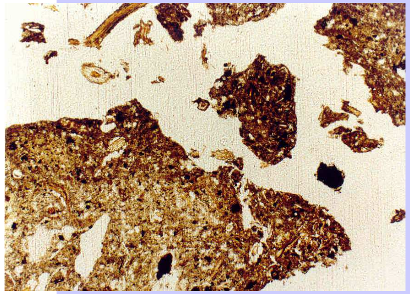


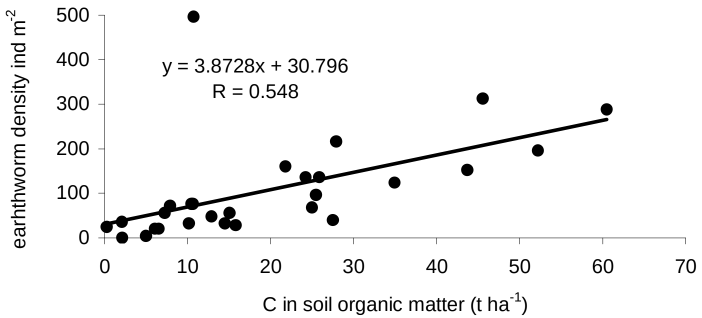
% of soil C in A layer
C in soil organic matter (tha-1)
y = 1.3339x + 45.587
R = 0.650

LF (Oa Oe)
A

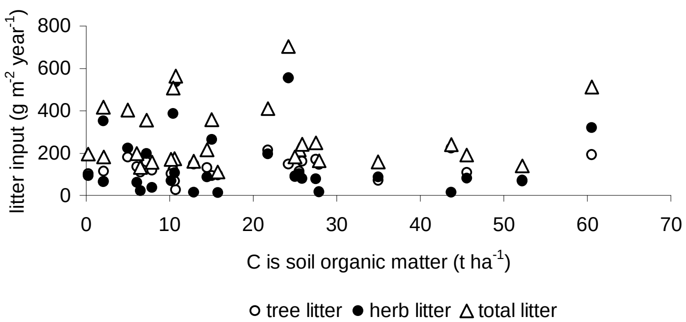


% of worm cast in soil volume
C in soil organic matter (t ha-1)
y = 0.3165x + 3.4588
R = 0.611

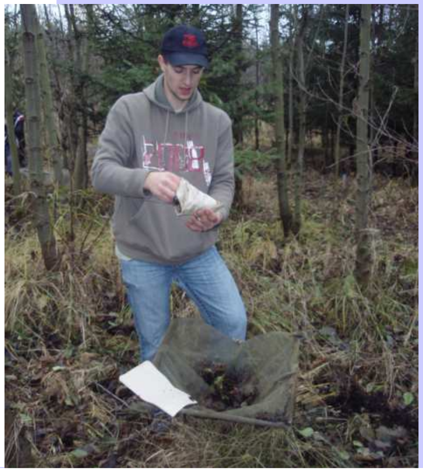




earthworm density ind m-2
C in soil organic matter (t ha-1)
y = 3.8728x + 30.796
R = 0.548



litter input (g m-2 year-1)
C is soil organic matter (t ha-1)
tree litter
herb litter
total litter

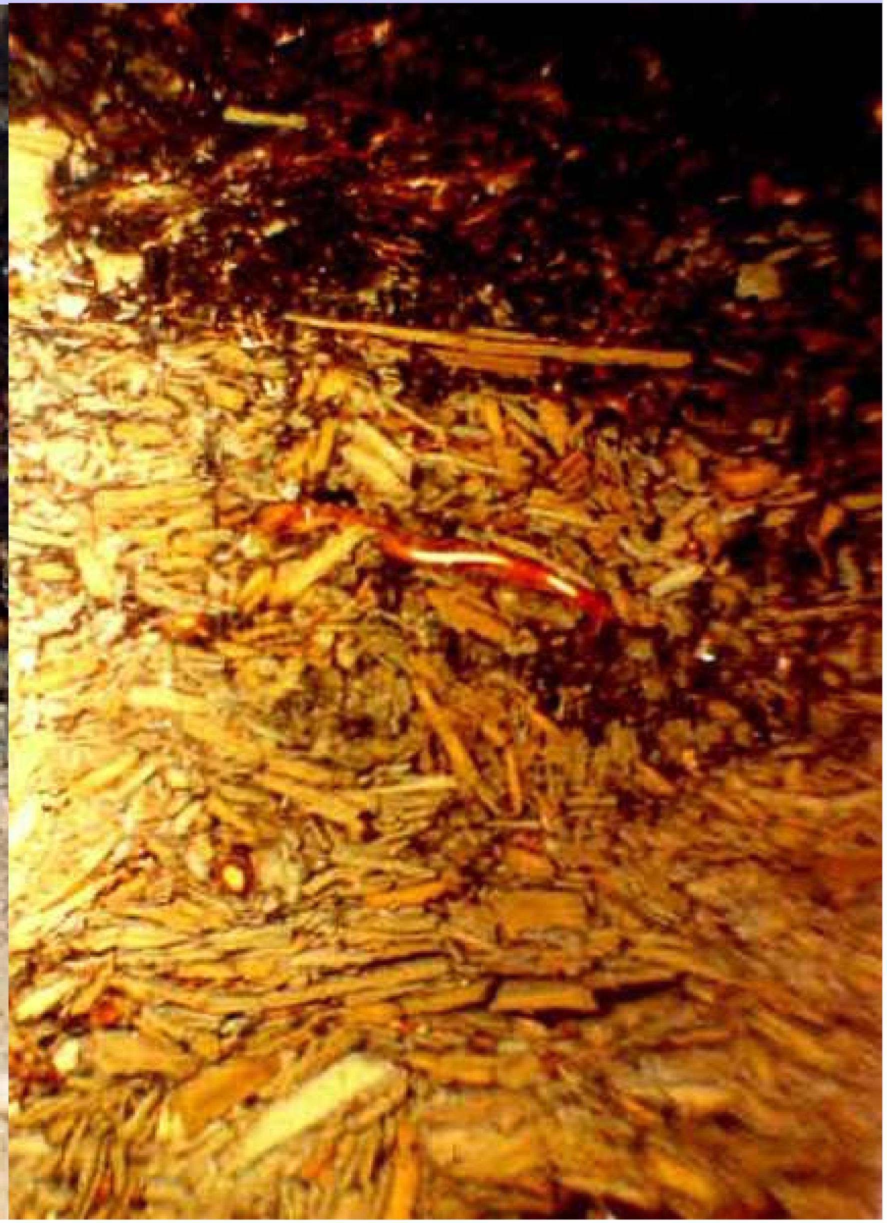


Location of study area and pictures of spontaneously developing sites (age of 11, 15 and 41 years).

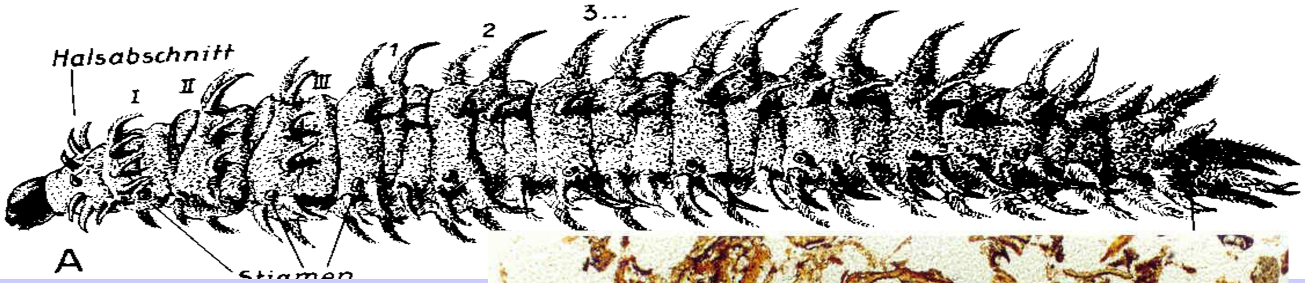
Reclaimed sites (alder plantations) heaped 14, 23 and 42 years ago

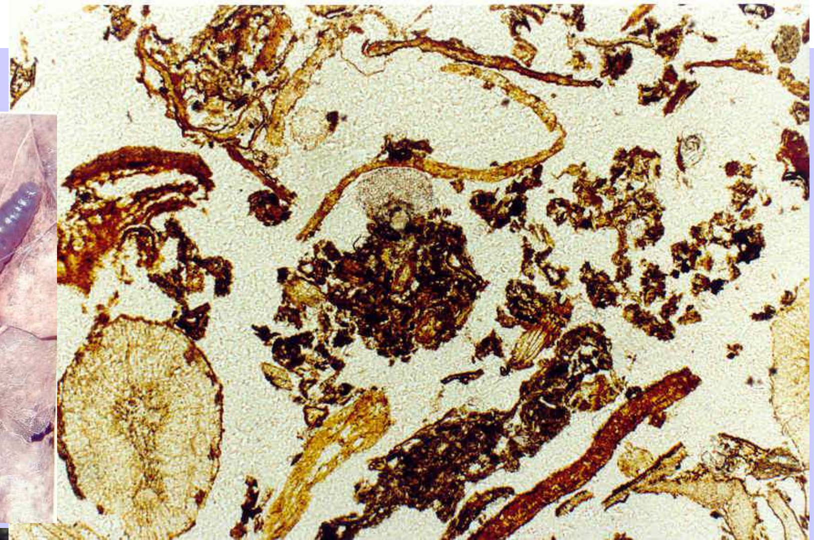
reclaimed

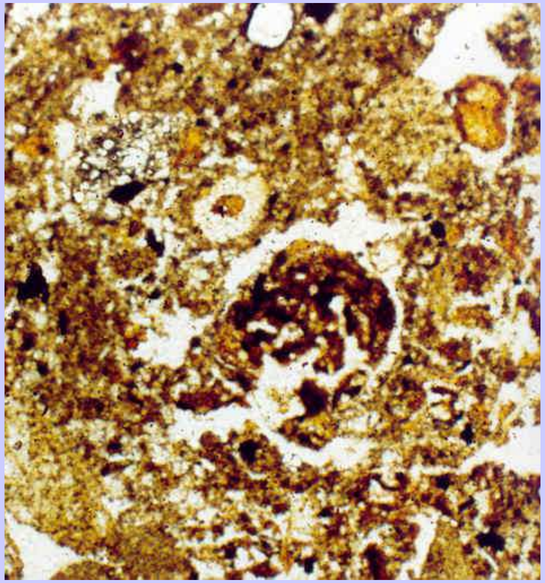
unreclaimed



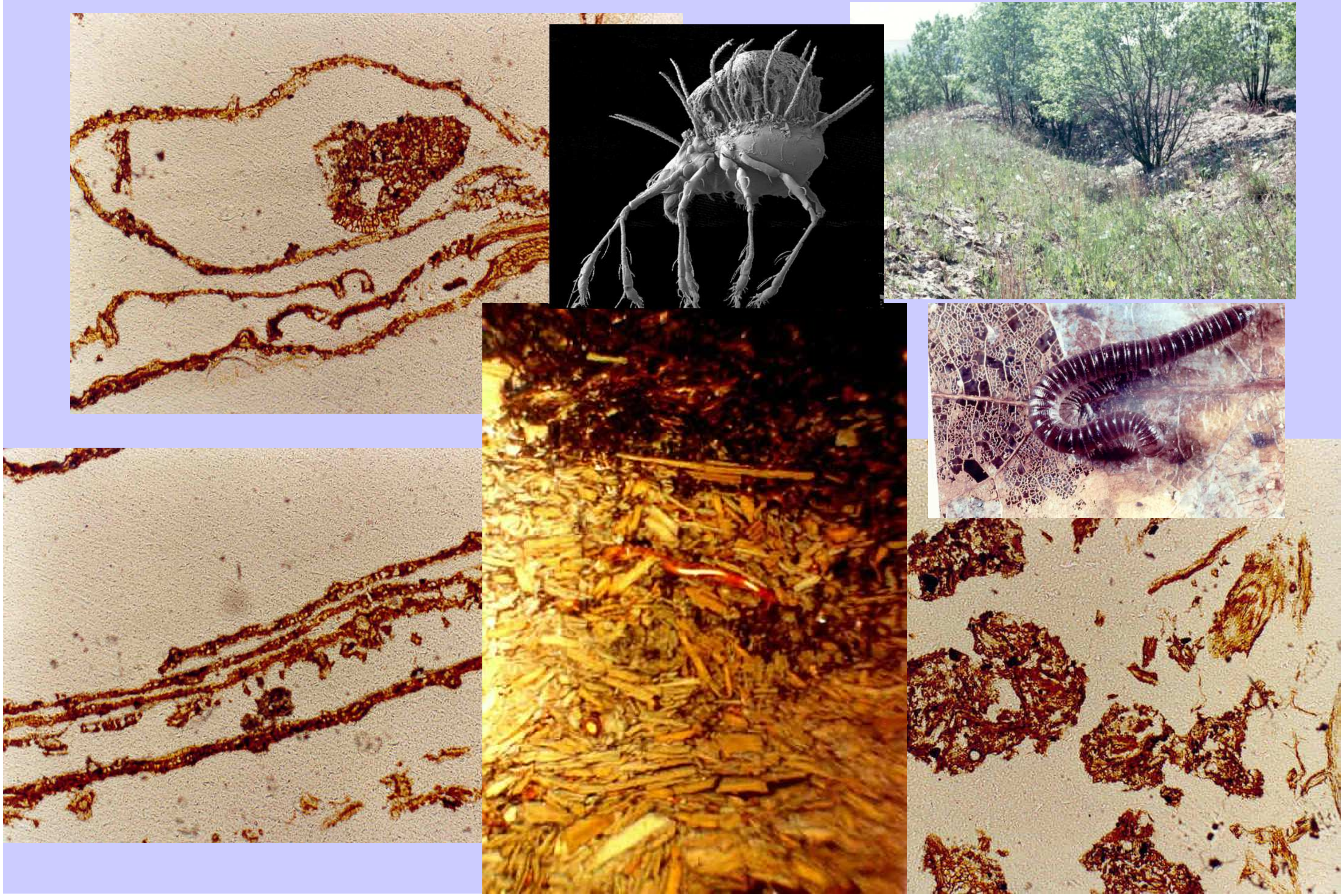
Reclaimed site
20 year old



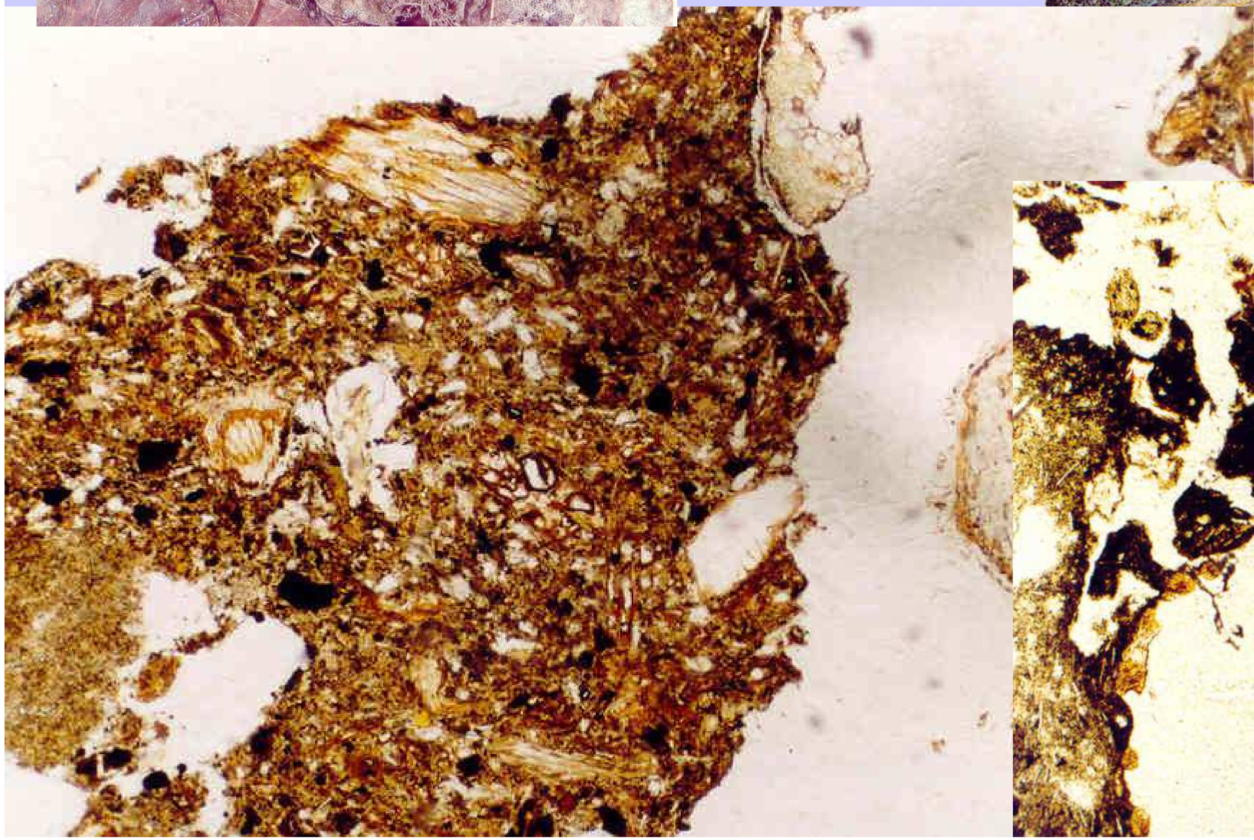


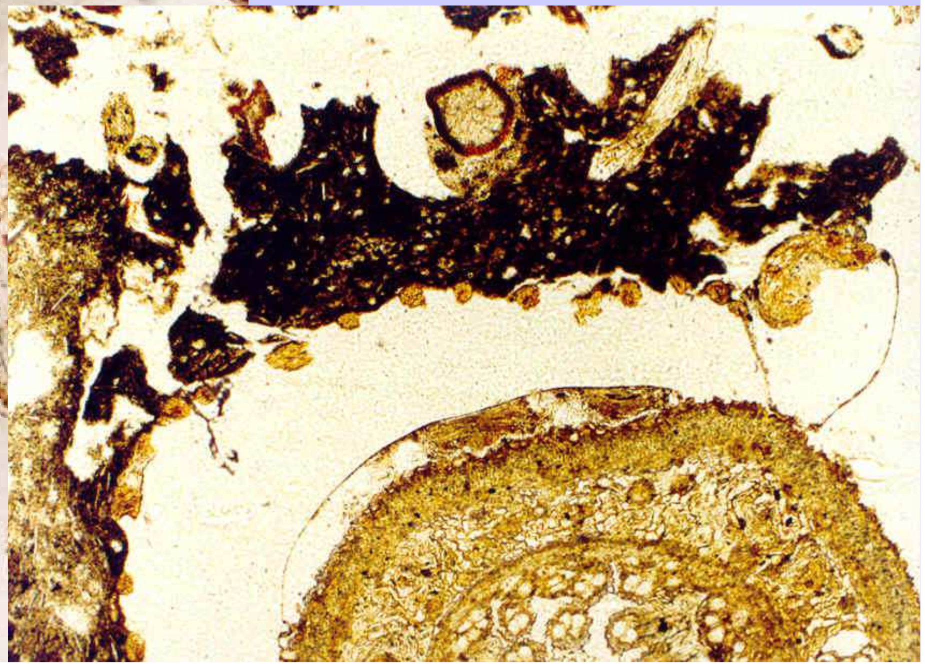


Spontaneous succession - unreclaimed 20 year old



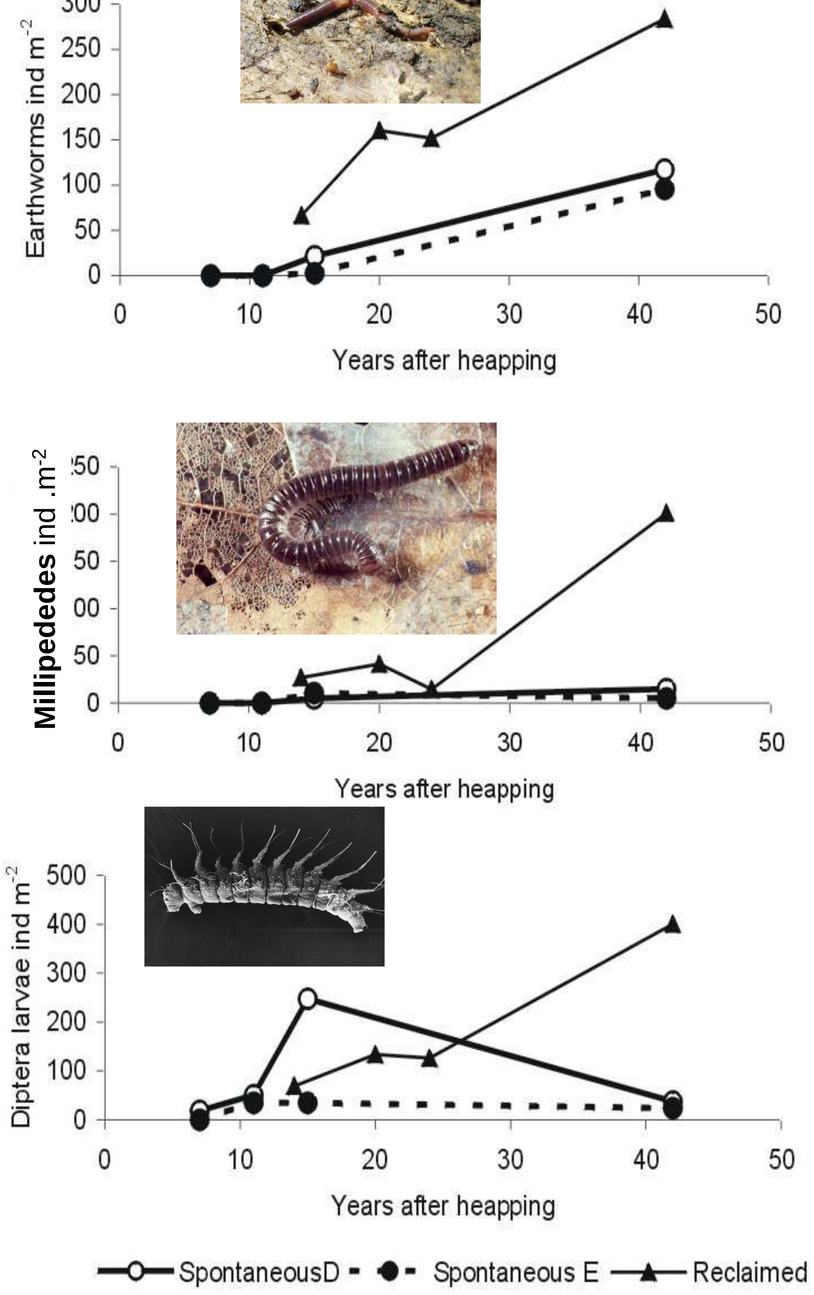
Spontaneous succession - 40 years old plot



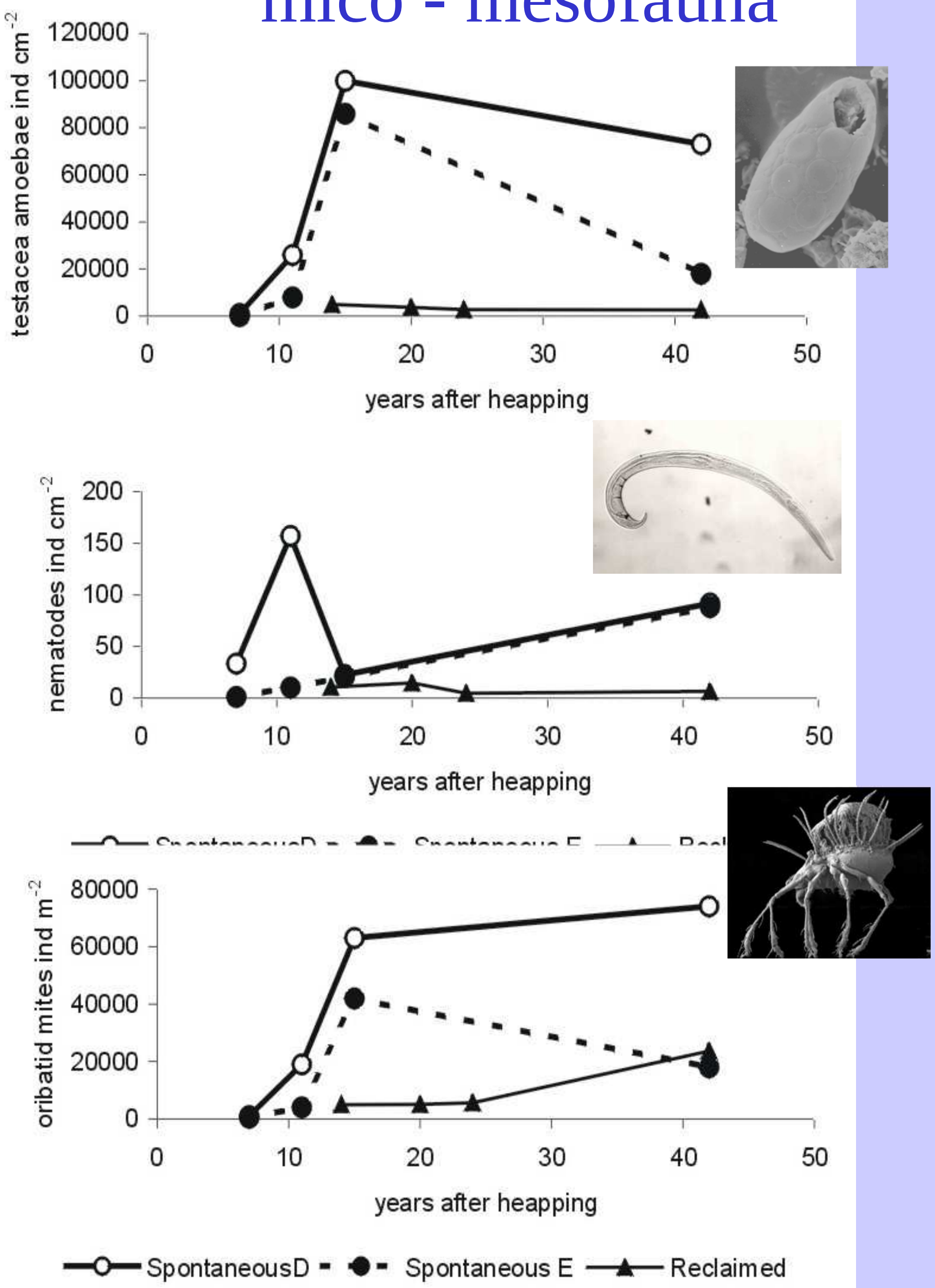


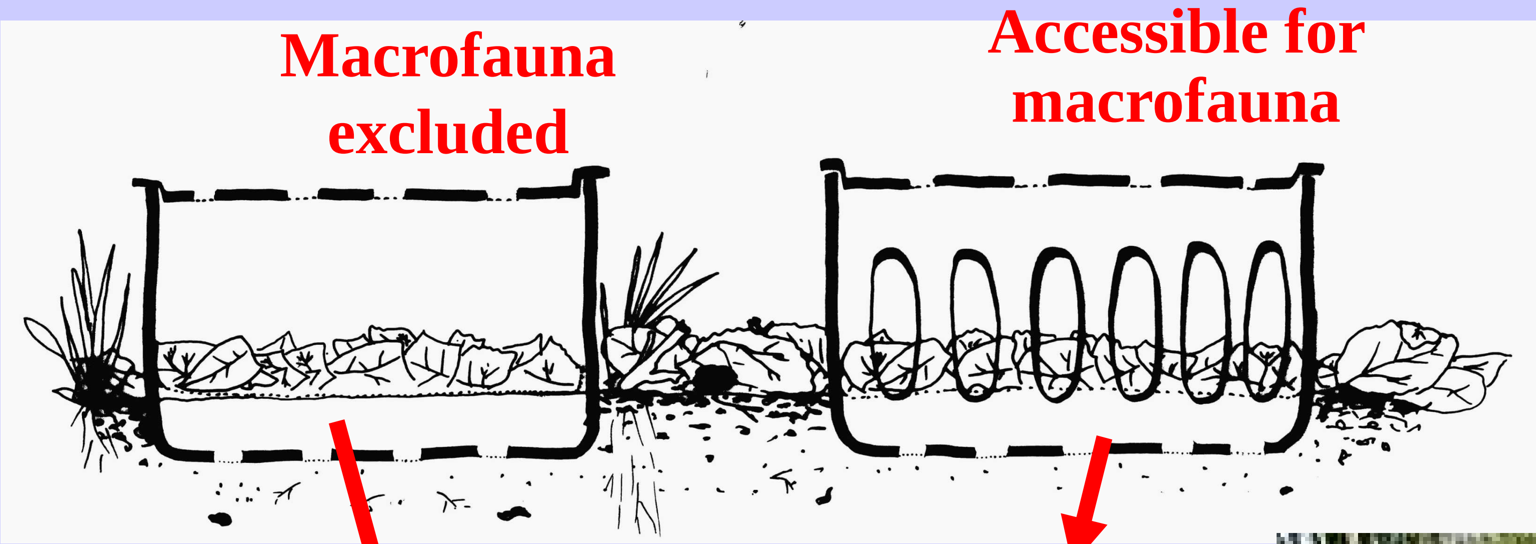
Soil fauna

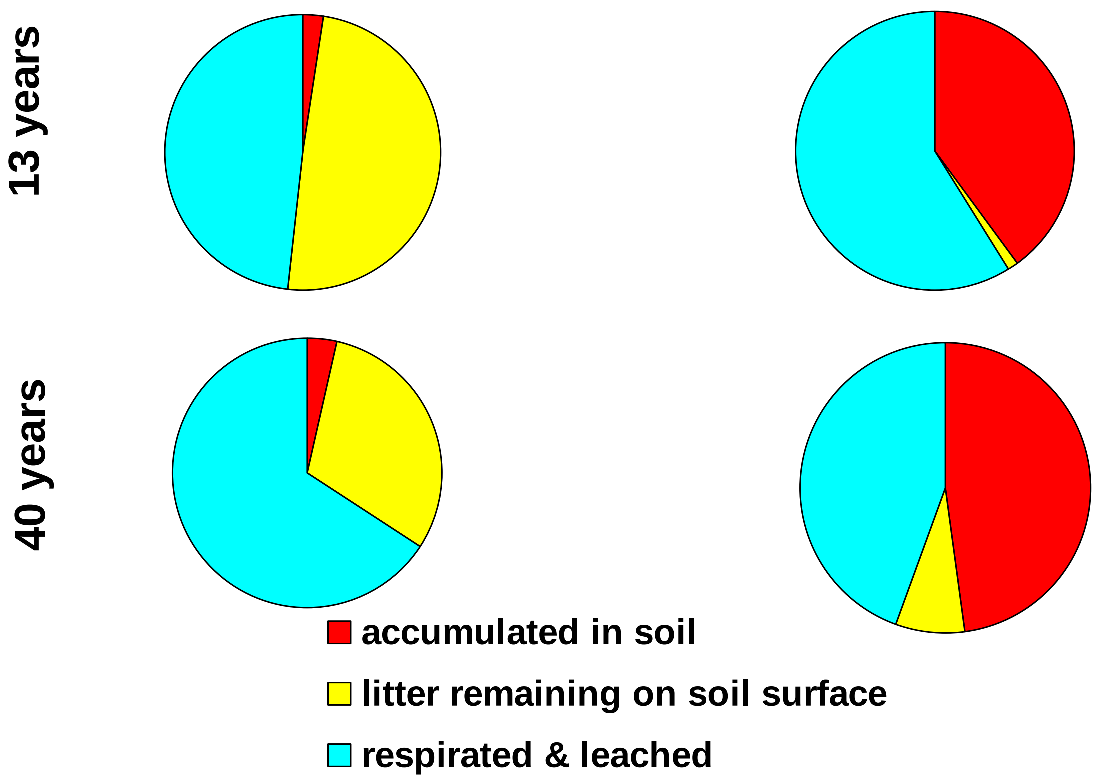
macrofauna

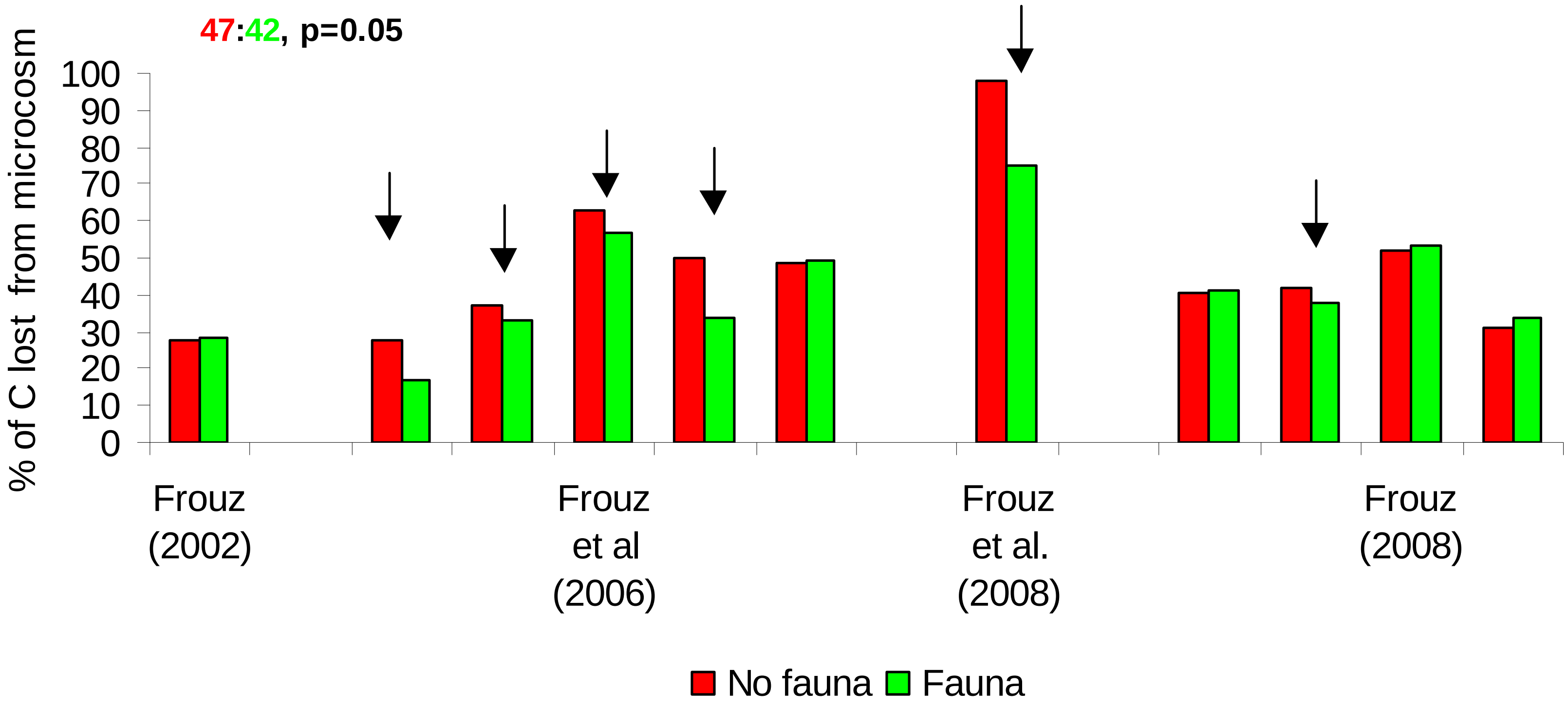


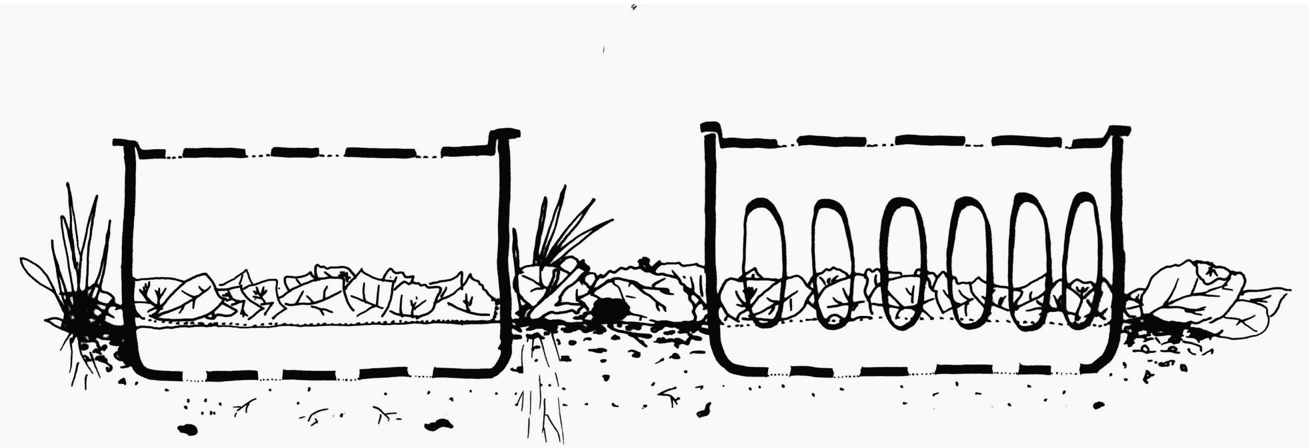
mico - mesofauna

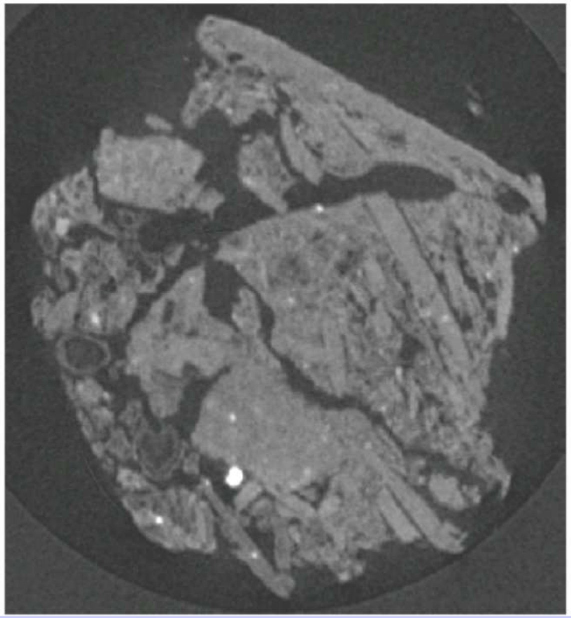


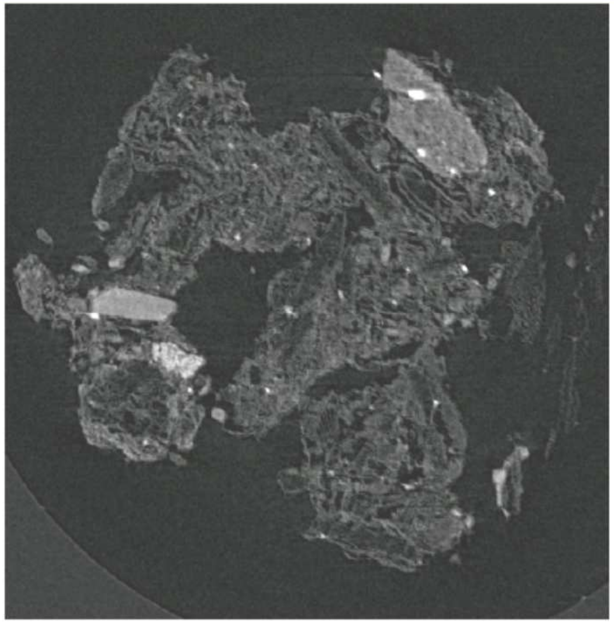

Macrofauna excluded
Accessible for macrofauna


13 years
40 years
accumulated in soil
litter remaining on soil surface
respirated & leached


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





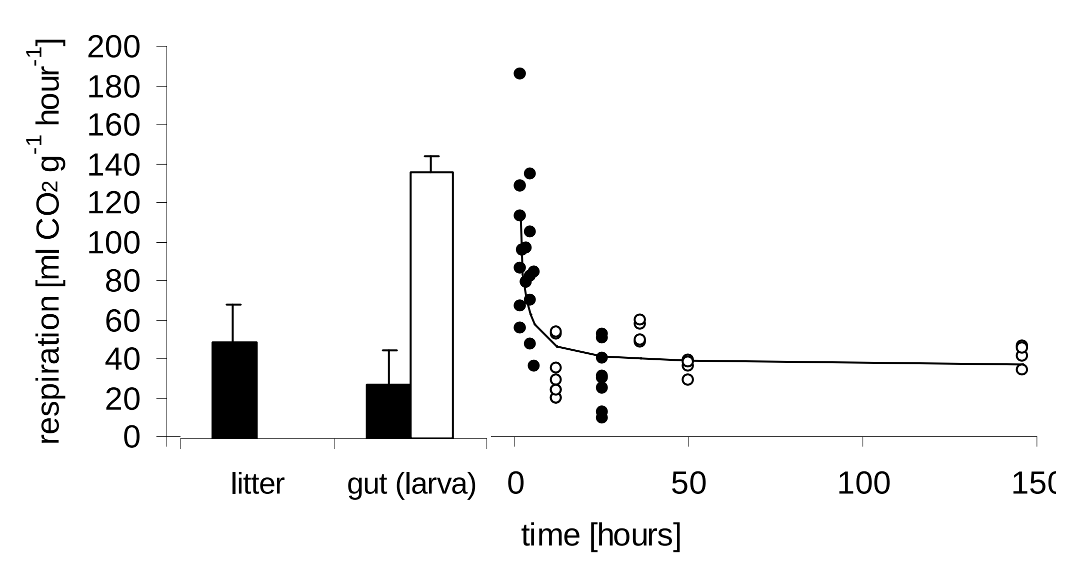


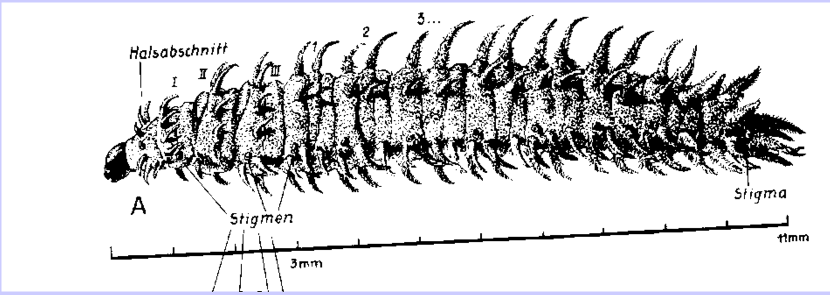
Other aggregates

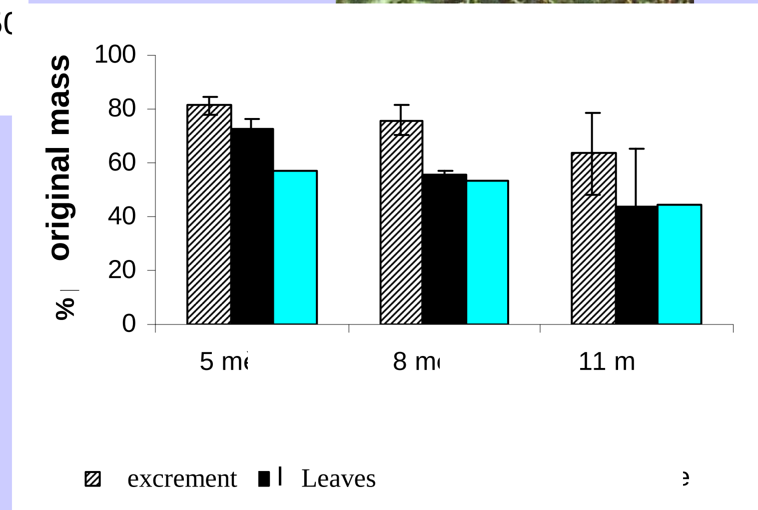
Earthworm created aggregates

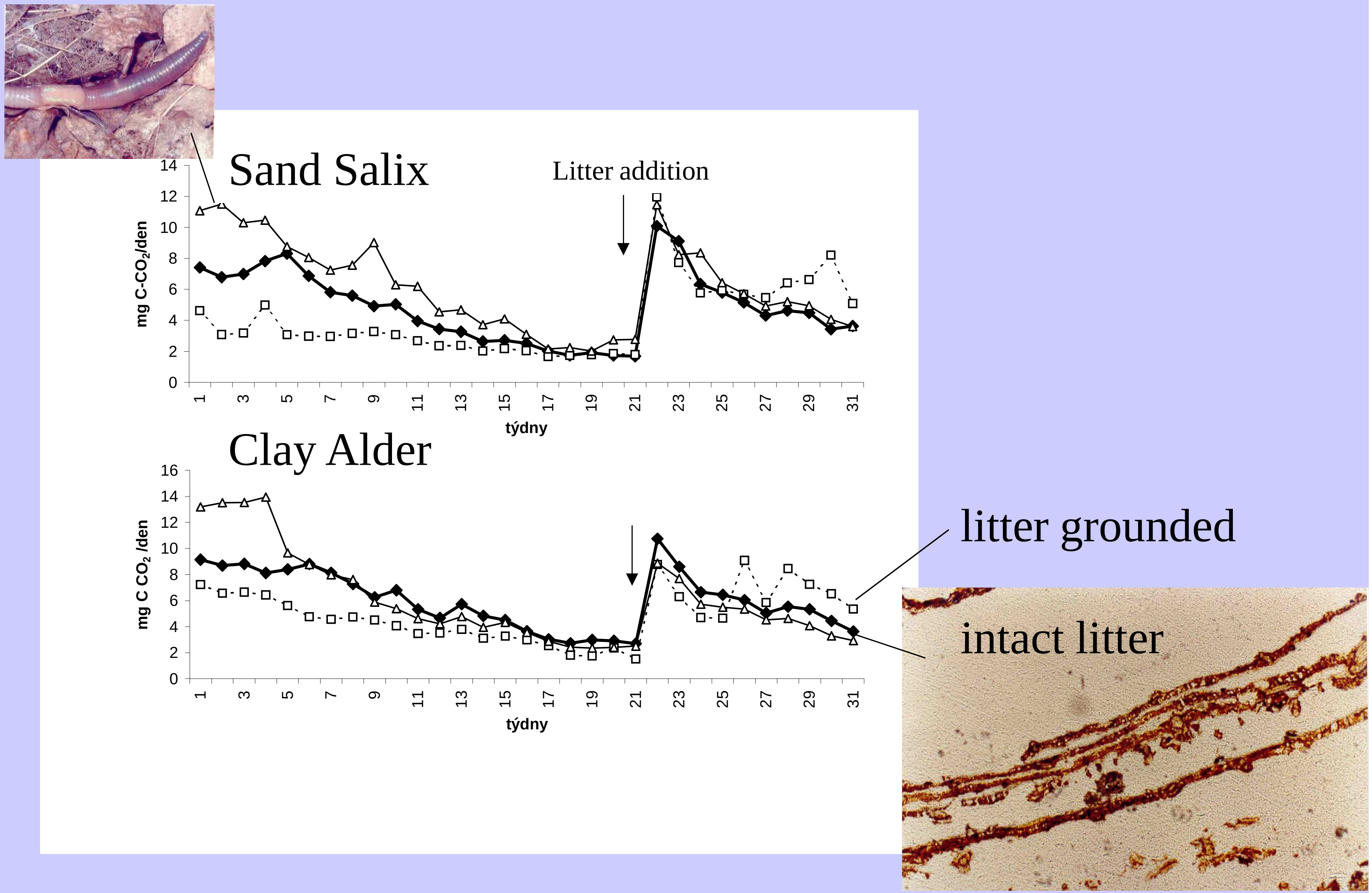
	prismatic	spherical
Light POM	0.34±0.21	0.84±0.55
Bounded light POM	0.18±0.12*	1.34±0.43*

In short term gut passage increased microbial respiration of excrement

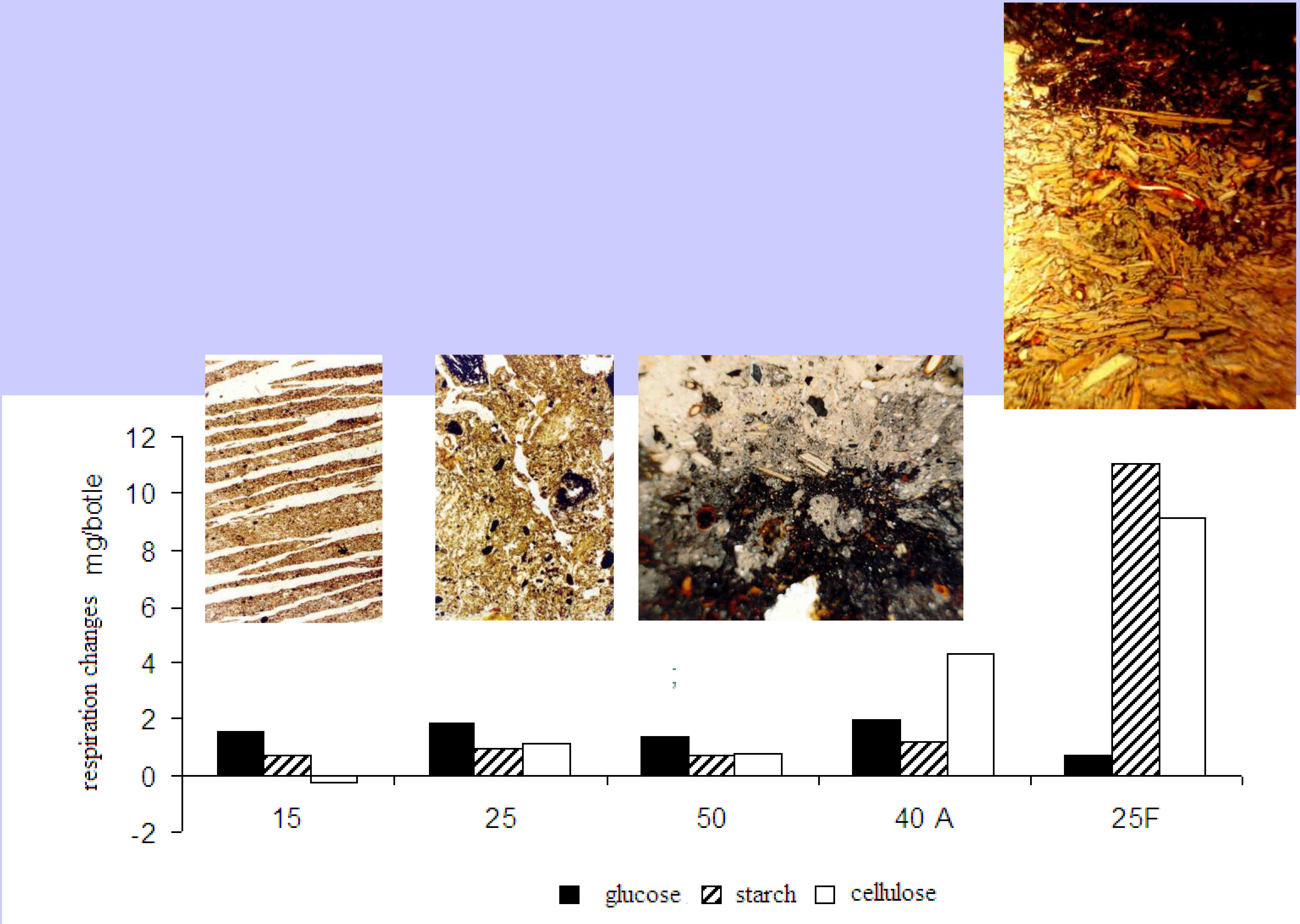


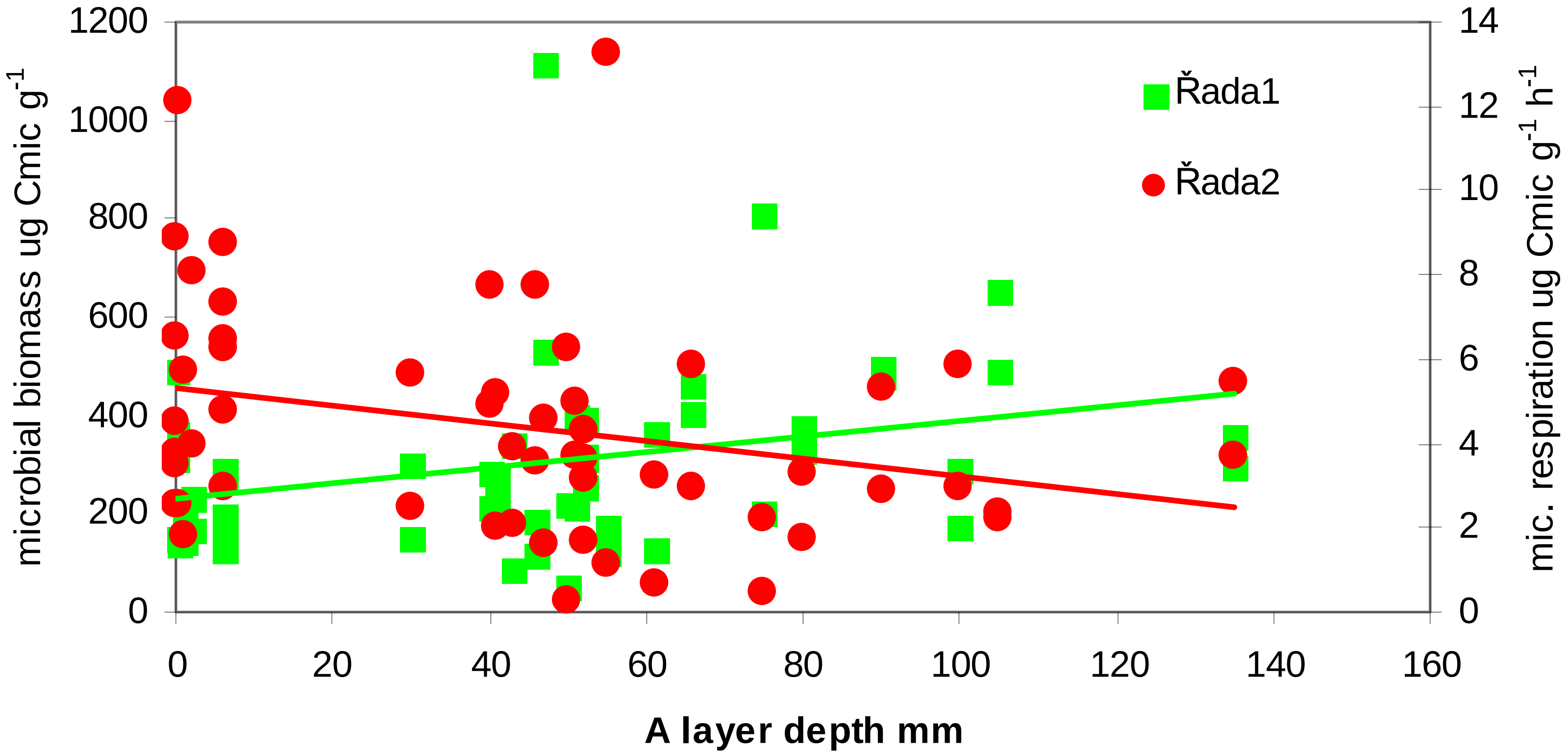





Sand Salix
Litter addition
mg C-CO2/den
týdny
Clay Alder
mg C CO2 /den
týdny
litter grounded
intact litter

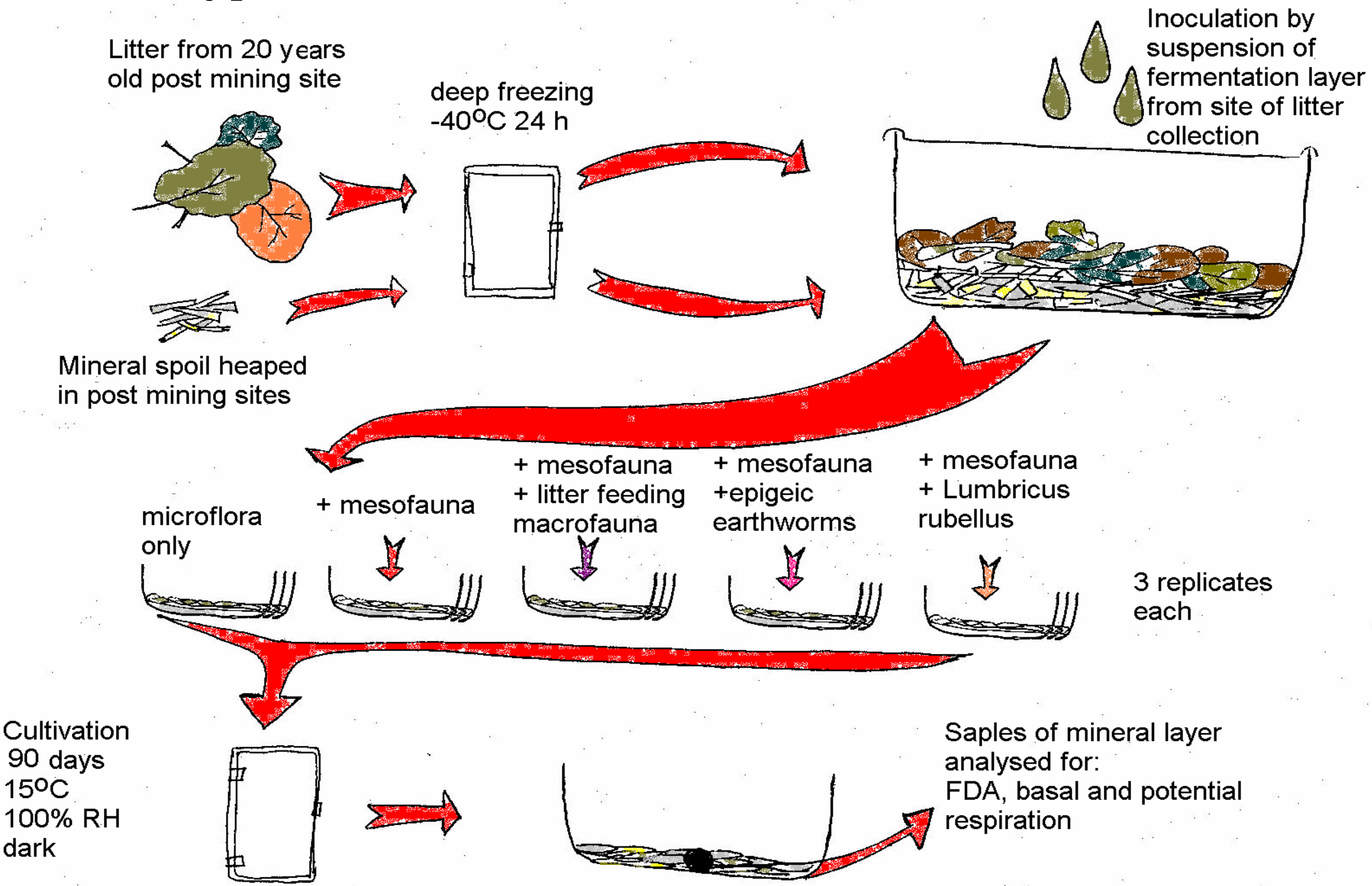
Priming effect is much bigger if liter is not mixed in soil



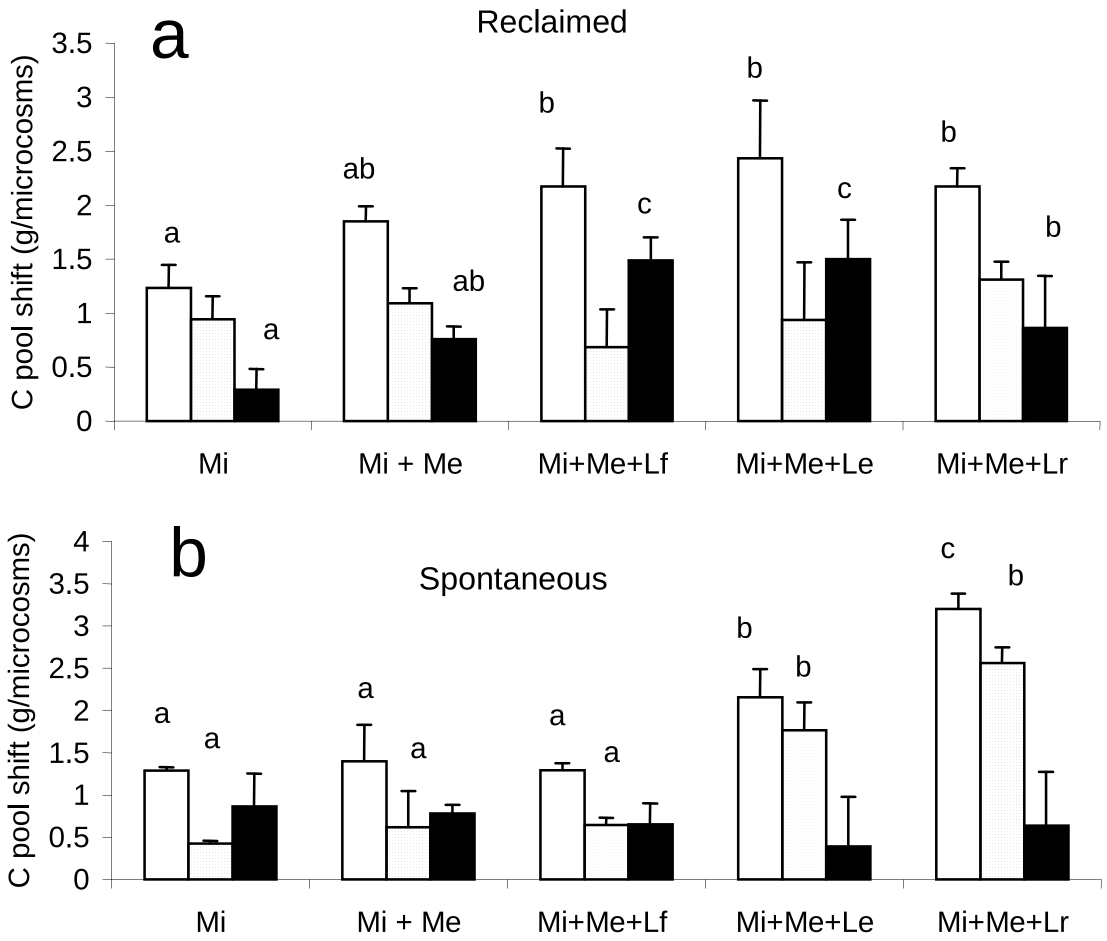


	biomass	respiration
pH KCl	-0.333	0.201
Cox	**0.601**	**-0.347**
tree cover	**0.271**	-0.177
F layer mm	**-0.398**	0.051
A layer mm	**0.317**	**-0.283**
worm cast	**0.445**	**-0.283**
earthworm dens.	**0.317**	-0.153
litter input	-0.153	0.041

Two types: reclaimed unreclaimed



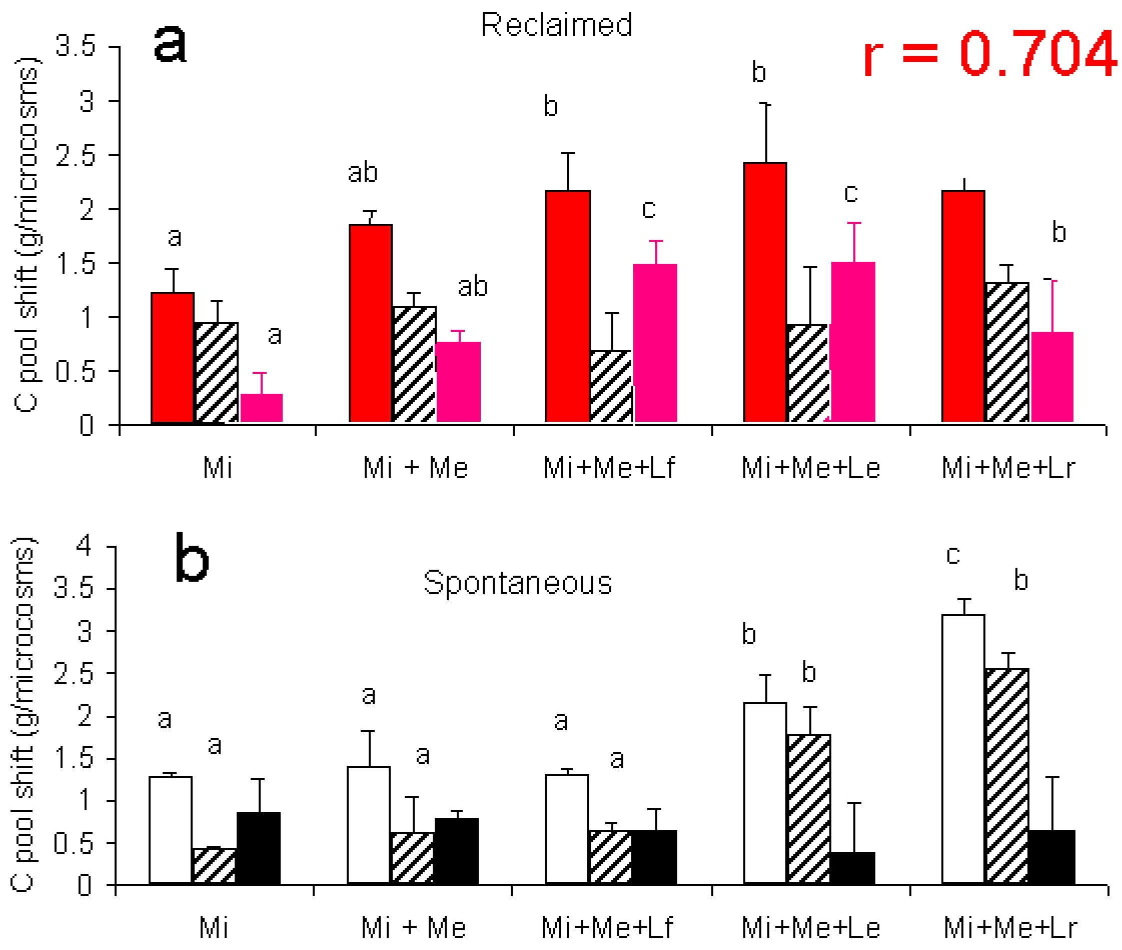
Scheme of experimental microcosms preparation and inoculation with various groups of soil fauna.



□ lost from litter — Litter ns, Fauna ***, L x F ** Mi,Me,Lf-a, Le-b, Lr-c

□ import to mineral — Litter ns, Fauna ***, L x F * Mi,Me-a, Lf-ab, Le-b, Lr-c

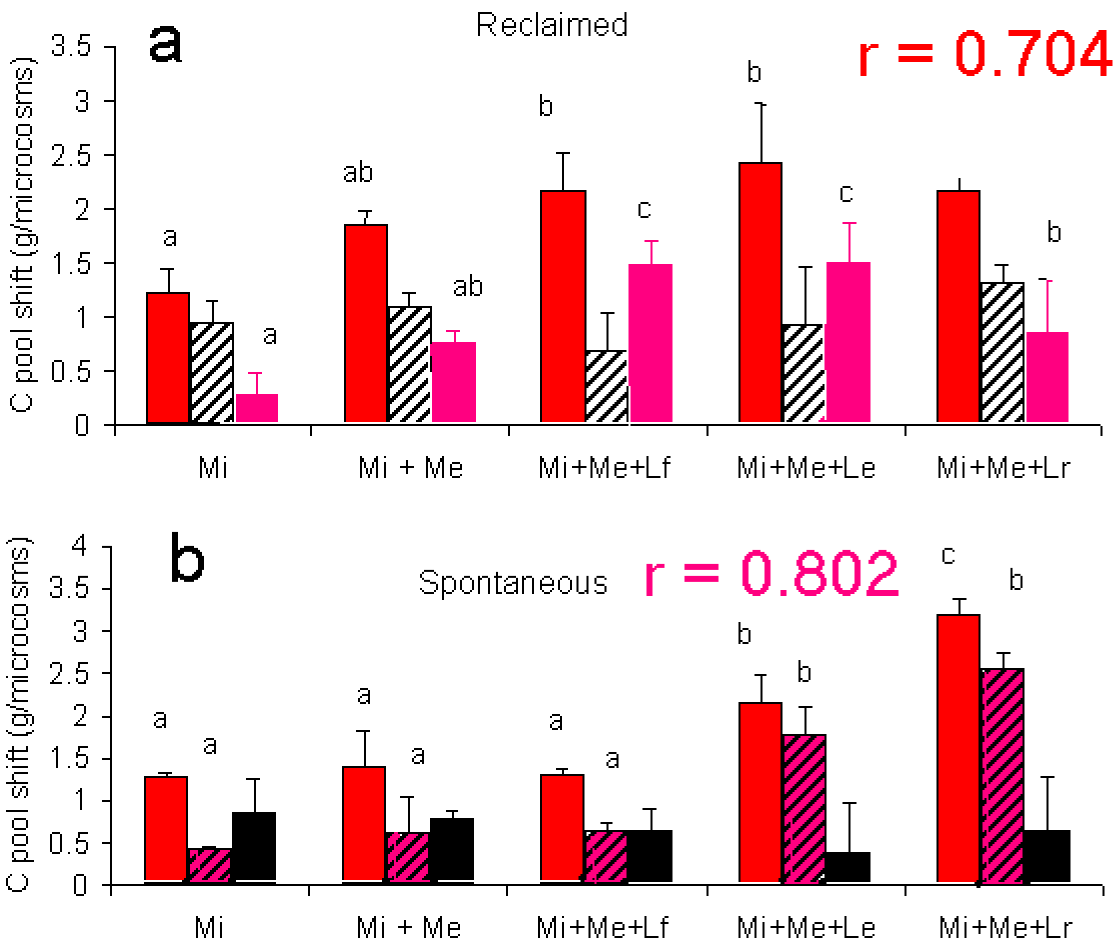
■ total loss — Litter ns, Fauna ns, L x F *



☐ lost from litter — Litter ns, Fauna ***, L x F ** Mi,Me,Lf-a, Le-b, Lr-c

▨ import to mineral — Litter ns, Fauna ***, L x F * Mi,Me-a, Lf-ab, Le-b, Lr-c

■ total loss — Litter ns, Fauna ns, L x F *

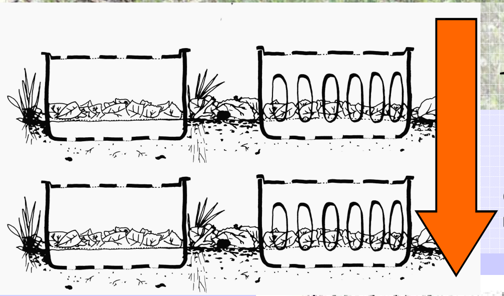


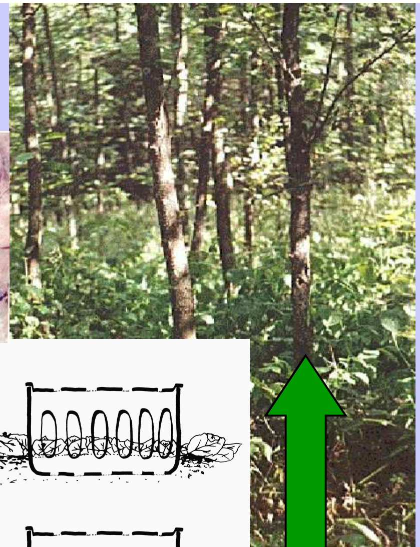
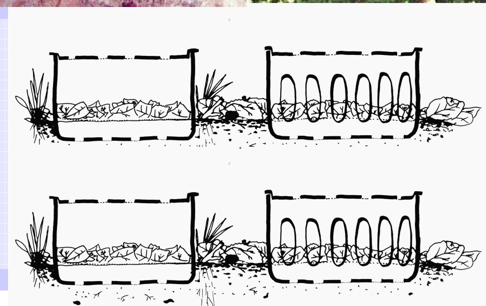
□ lost from litter — Litter ns, Fauna ***, L x F ** Mi,Me,Lf-a, Le-b, Lr-c

▨ import to mineral — Litter ns, Fauna ***, L x F * Mi,Me-a, Lf-ab, Le-b, Lr-c

■ total loss — Litter ns, Fauna ns, L x F *



Alder litter

Salix litter

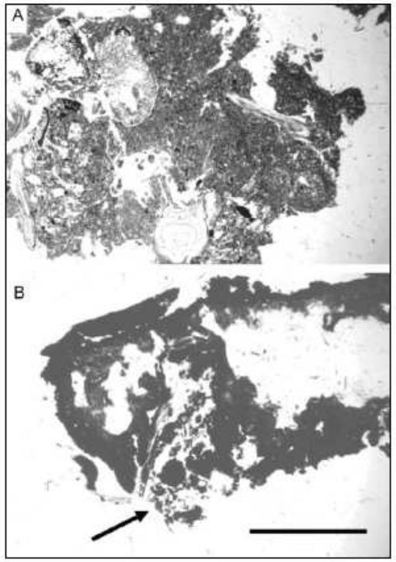


Fig. 2. Thin soil sections from the surface of the mineral layer of field microcosms that were exposed for one year. A – Treatment supplied with alder litter, exposed at the alder plantation and accessible for soil macro fauna; it was completely filled with earthworm cast. B – Treatment exposed in the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

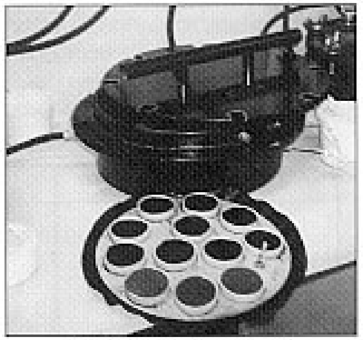
Table 1. Carbon content in the mineral layer and changes of carbon stock in the litter and mineral layers (mean ± SD) of field microcosms exposed for one year either in the alder plantation (A) or in sites covered by spontaneous succession (S) supplied either with alder litter or litter from a spontaneous 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

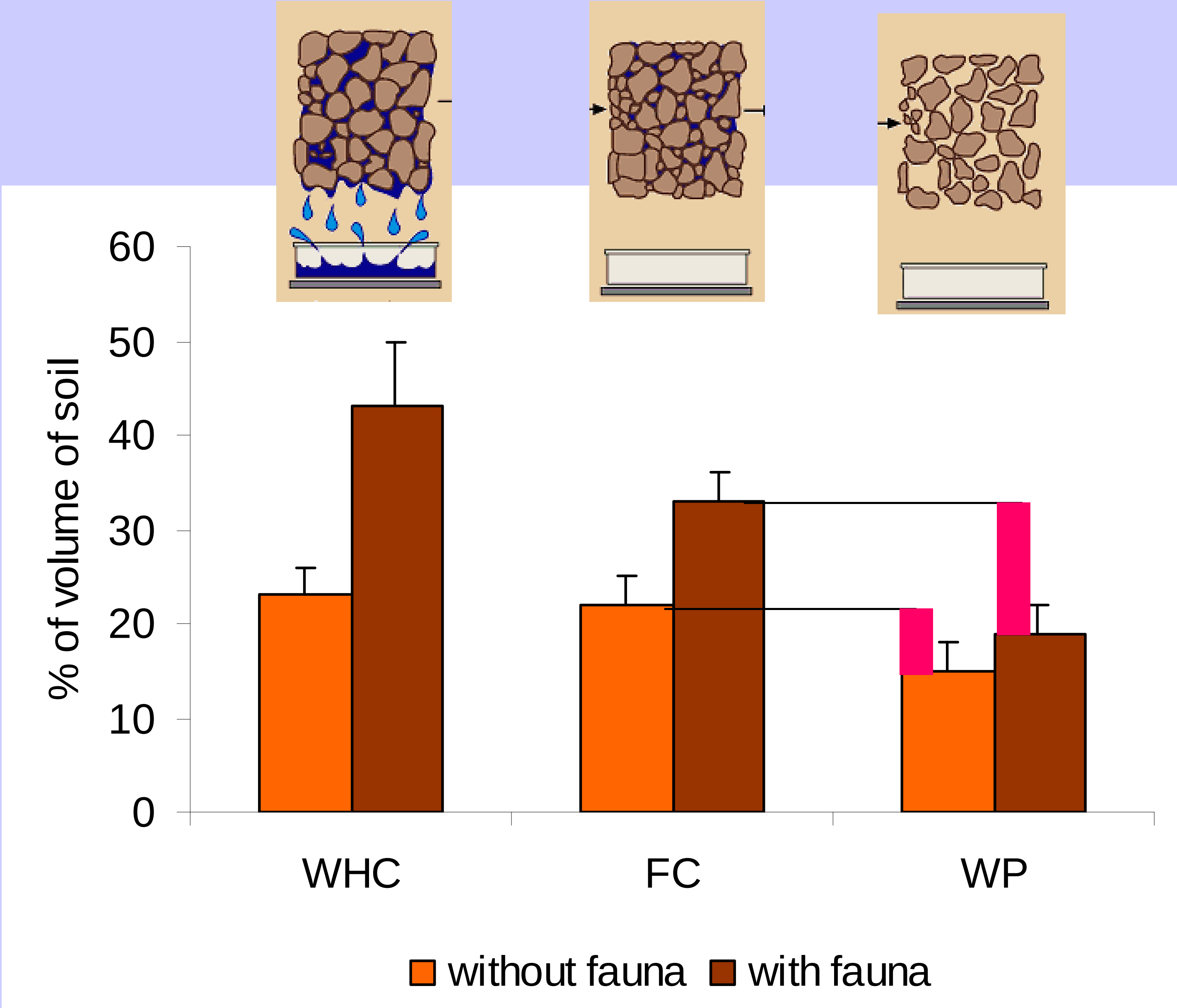
Explanations: * Indicates a significant difference between fauna accessible and non accessible treatment (t- test, $P < 0.05$). The bottom of the table summarises F (the first column for each parameter) and P (the second column) values of three-way ANOVA for individual factors and their interactions,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

Effect of SOM accumulation on soil water budget

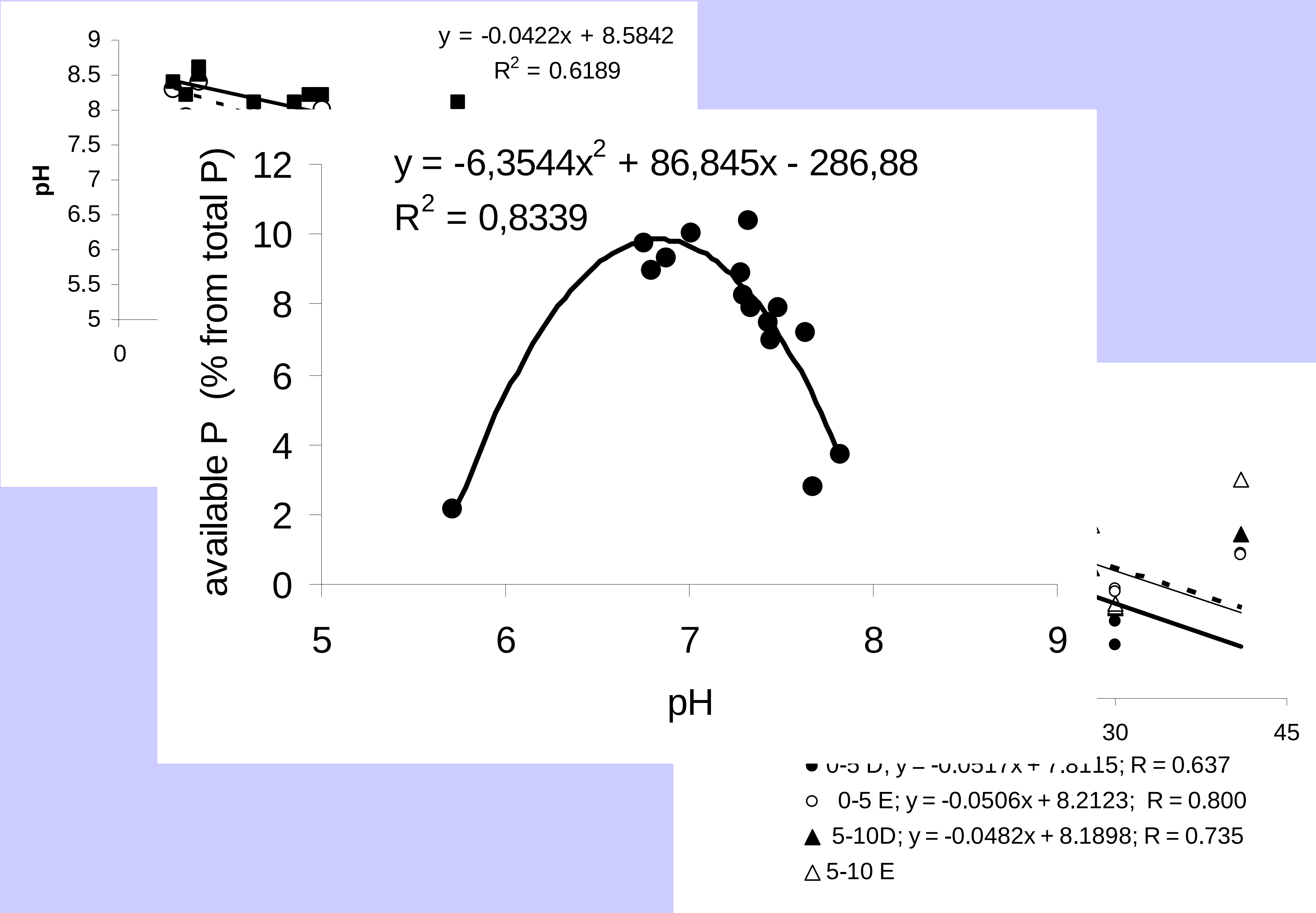


15 Bar laboratory apparatus

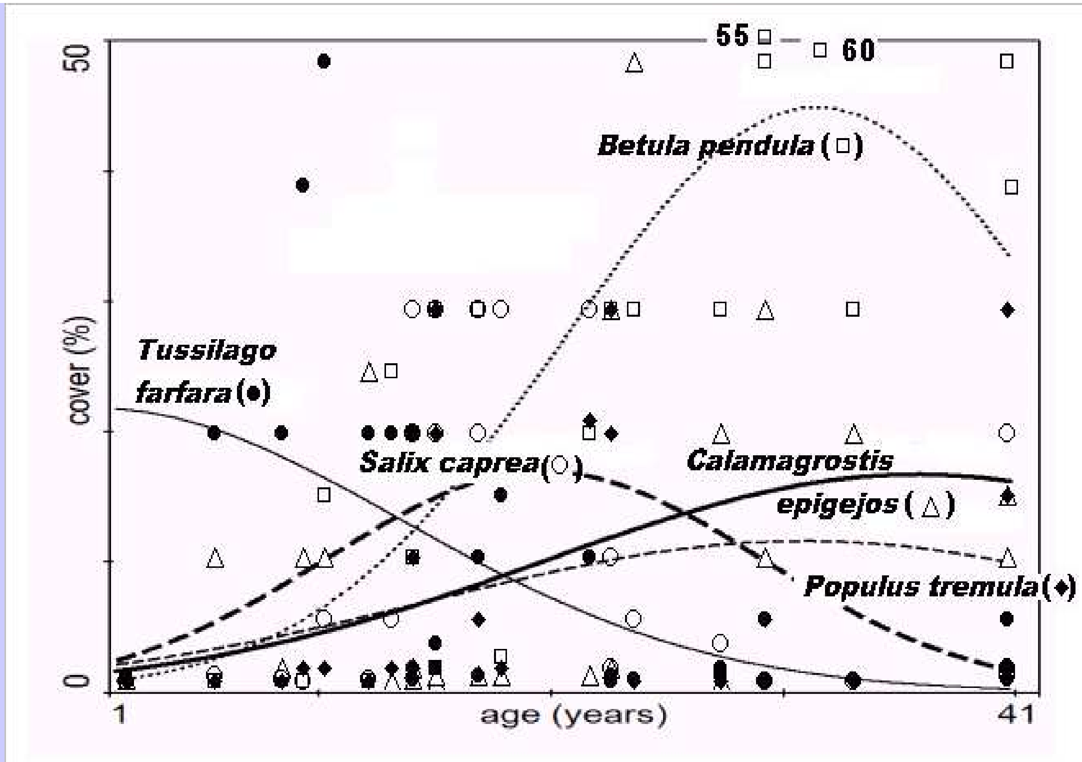
1/3 (.333) Bar laboratory apparatus

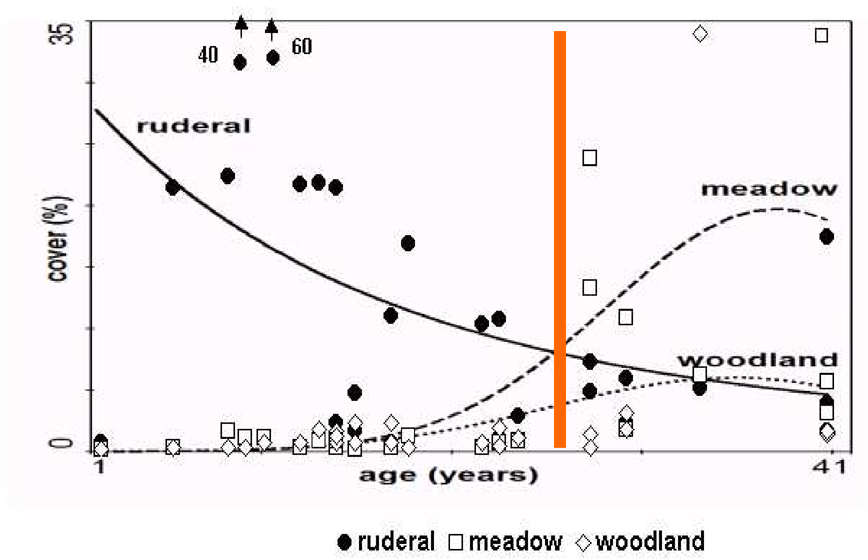


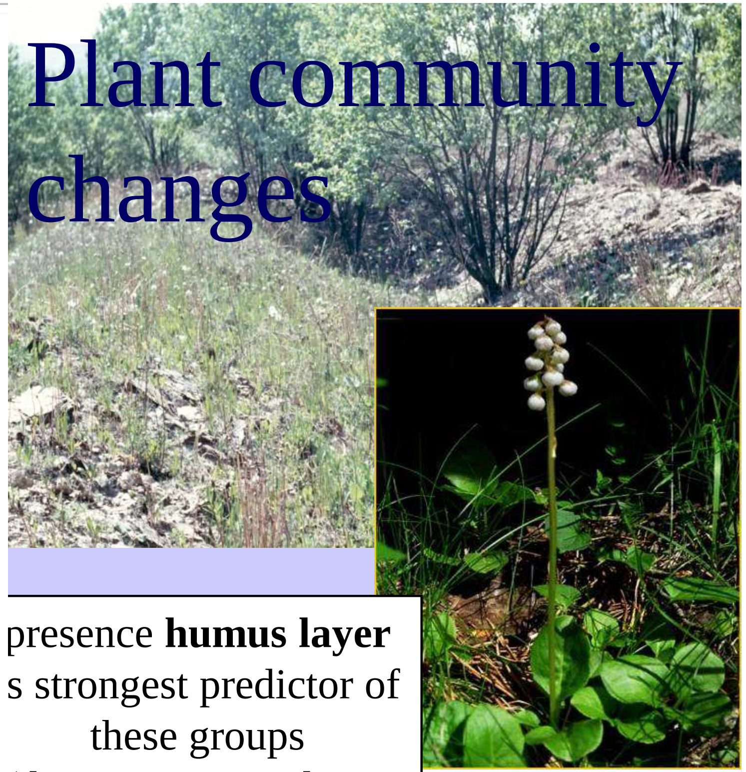
Effect of SOM accumulation on soil chemical properties



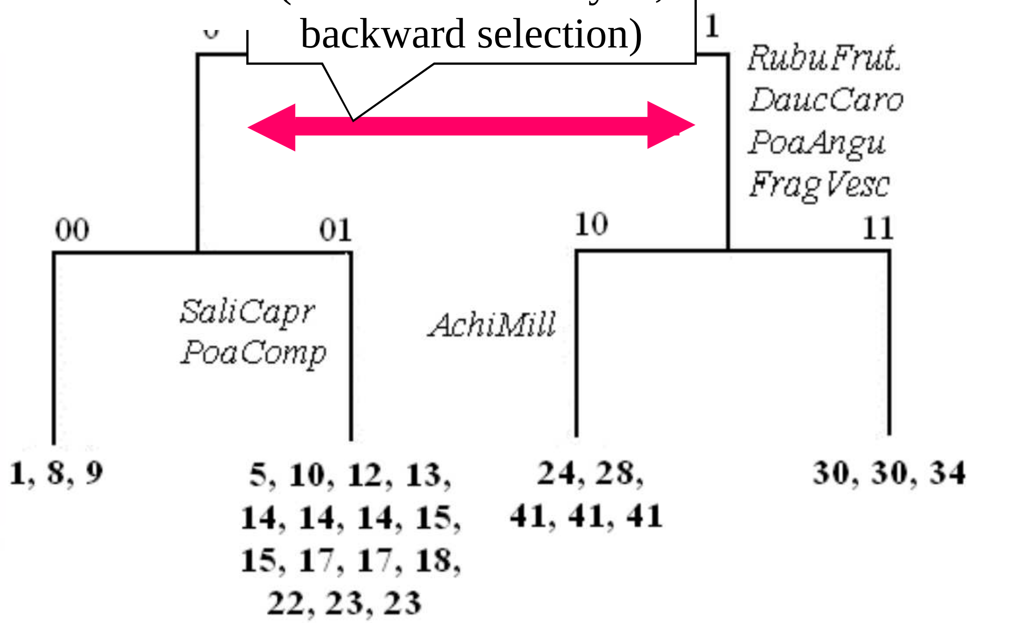
Plant community changes

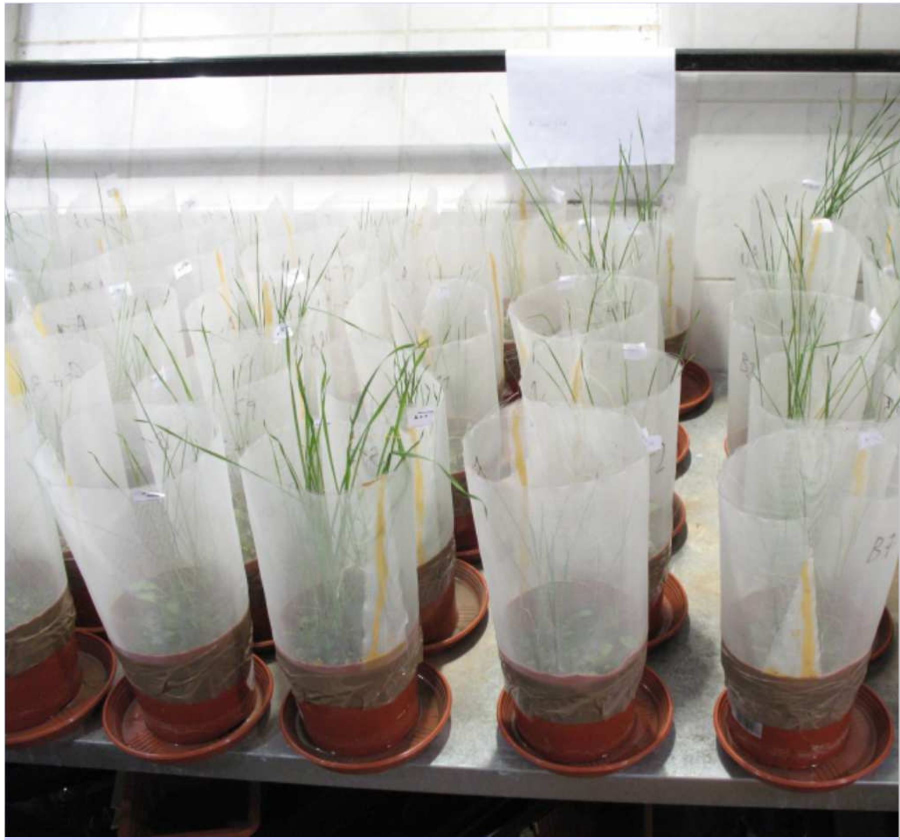


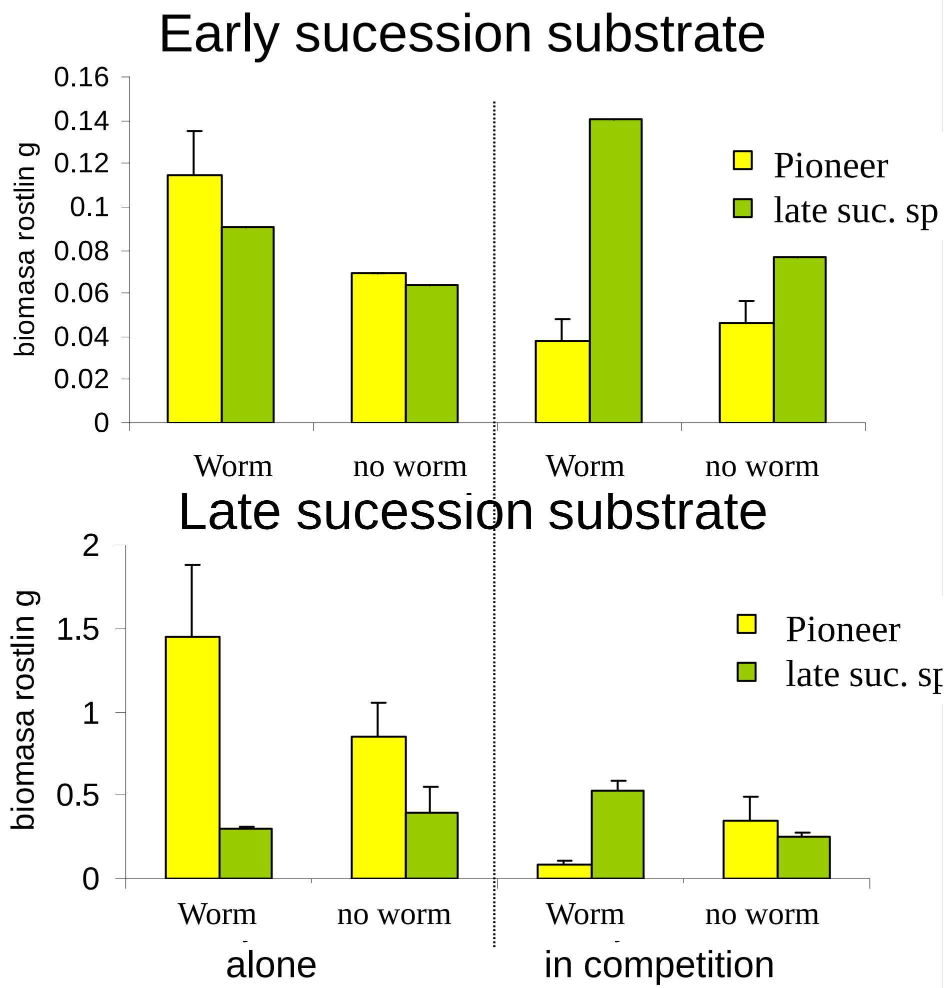




presence **humus layer** is strongest predictor of these groups (discriminant analysis, backward selection)



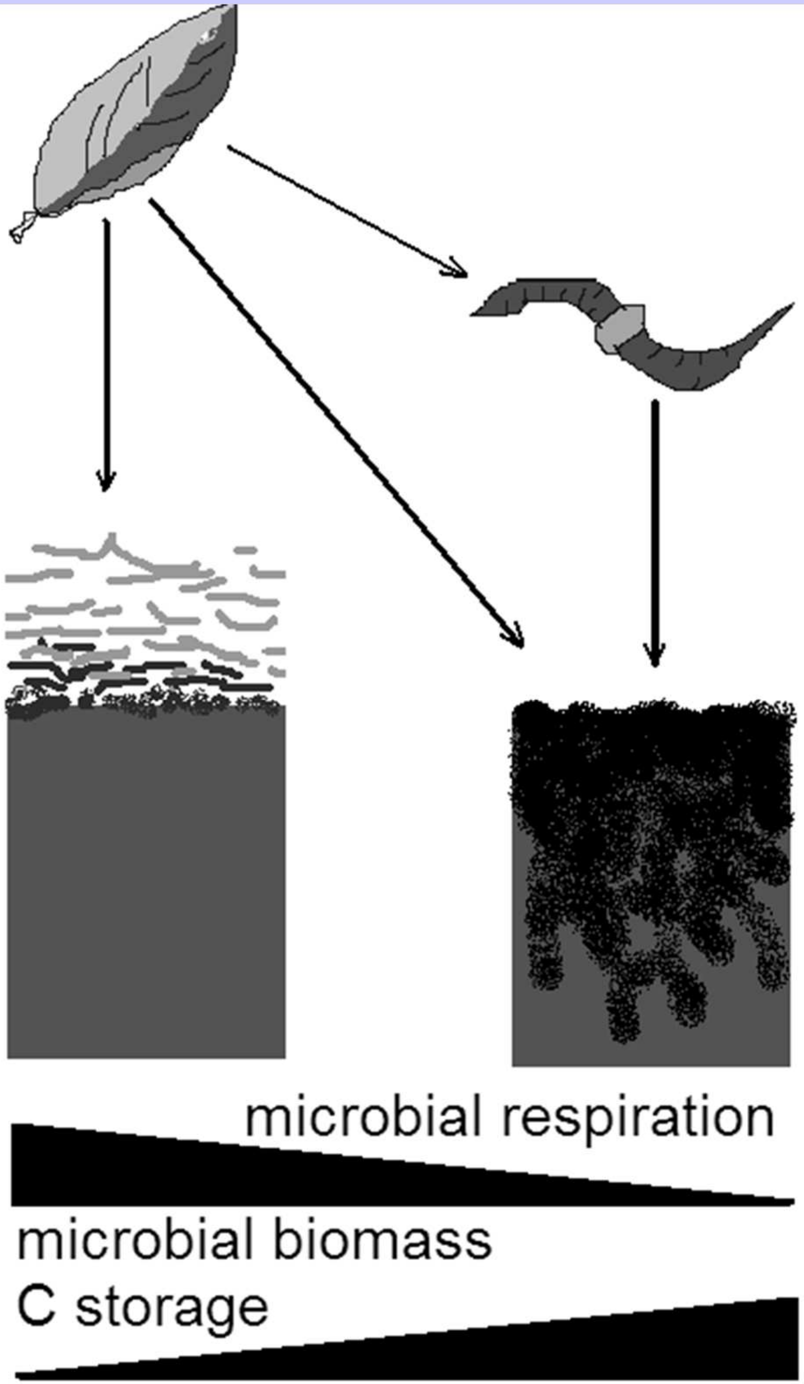


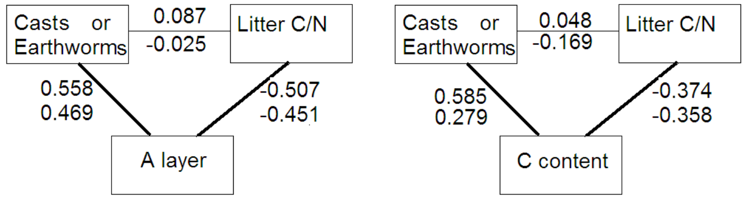

Early sucession substrate
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
biomasa rostlin g
Pioneer
late suc. sp
Worm
no worm
Worm
no worm
Late sucession substrate
2
1.5
1
0.5
0
biomasa rostlin g
Pioneer
late suc. sp
Worm
no worm
Worm
no worm
alone
in competition

What are the possibilities for remote sensing?

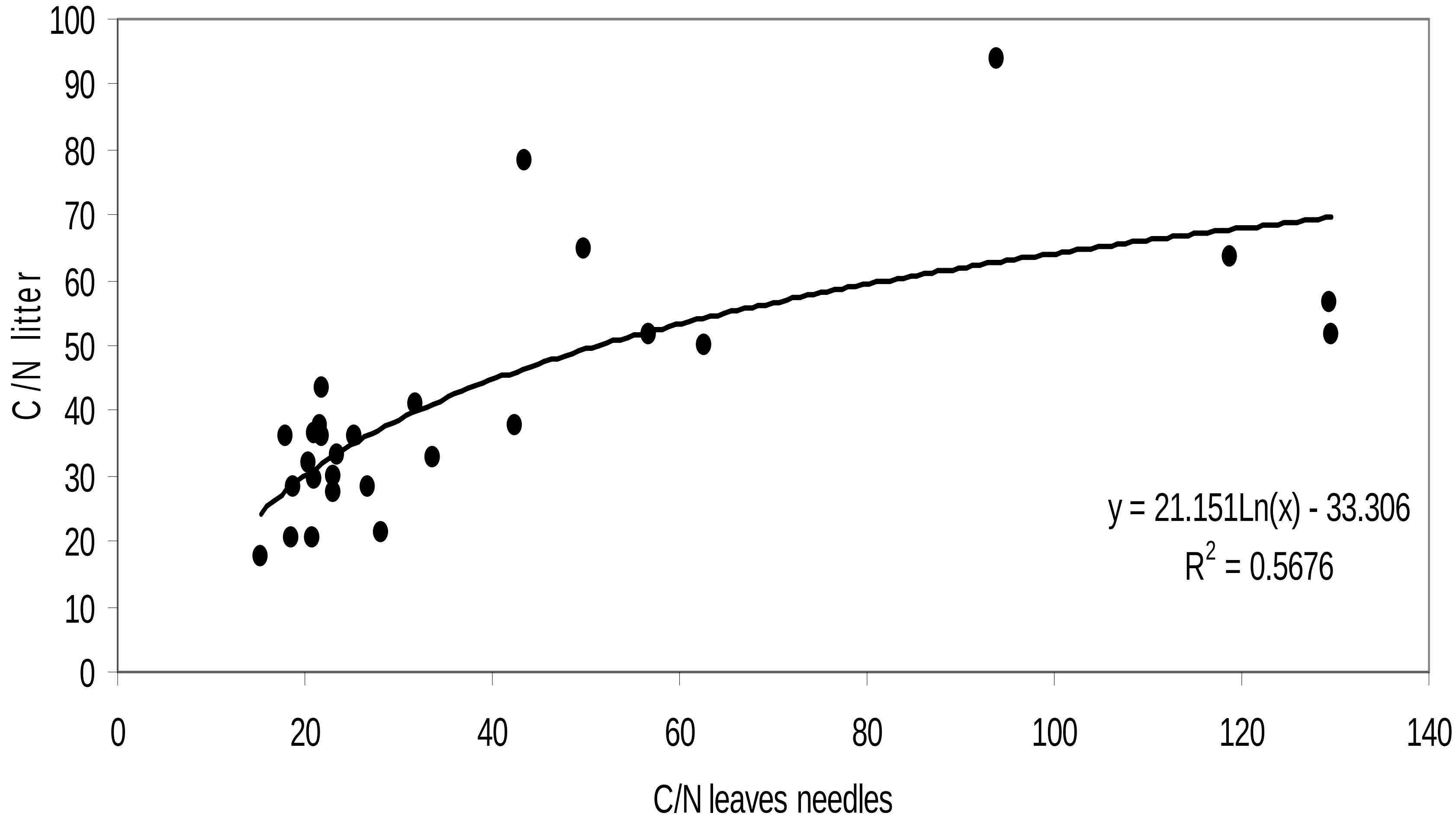
Bare soil

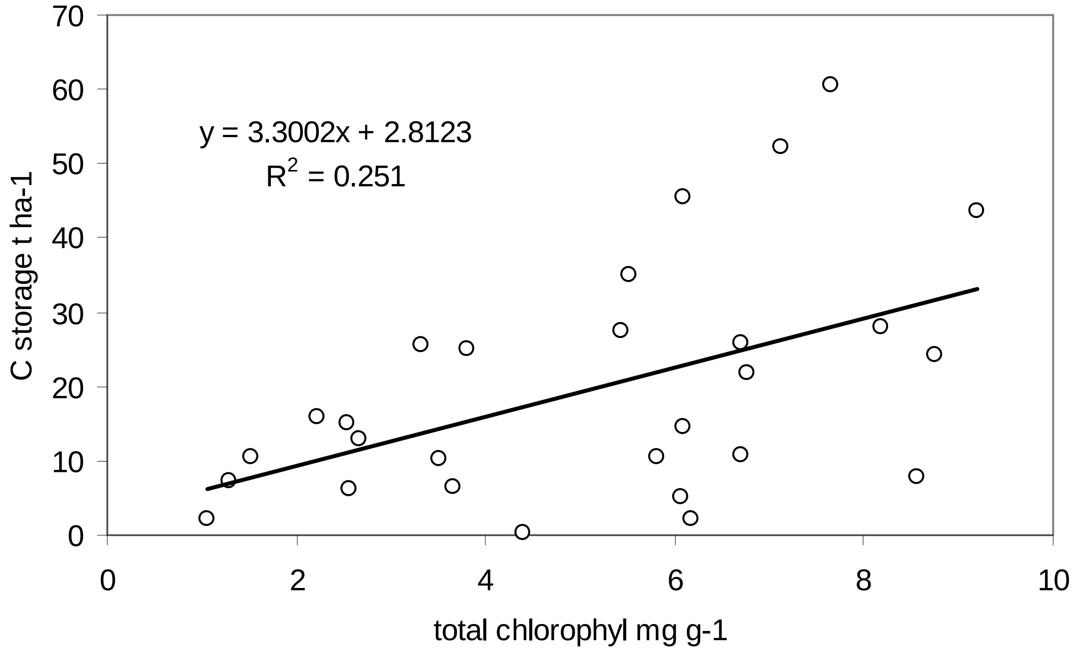
Soil under vegetation

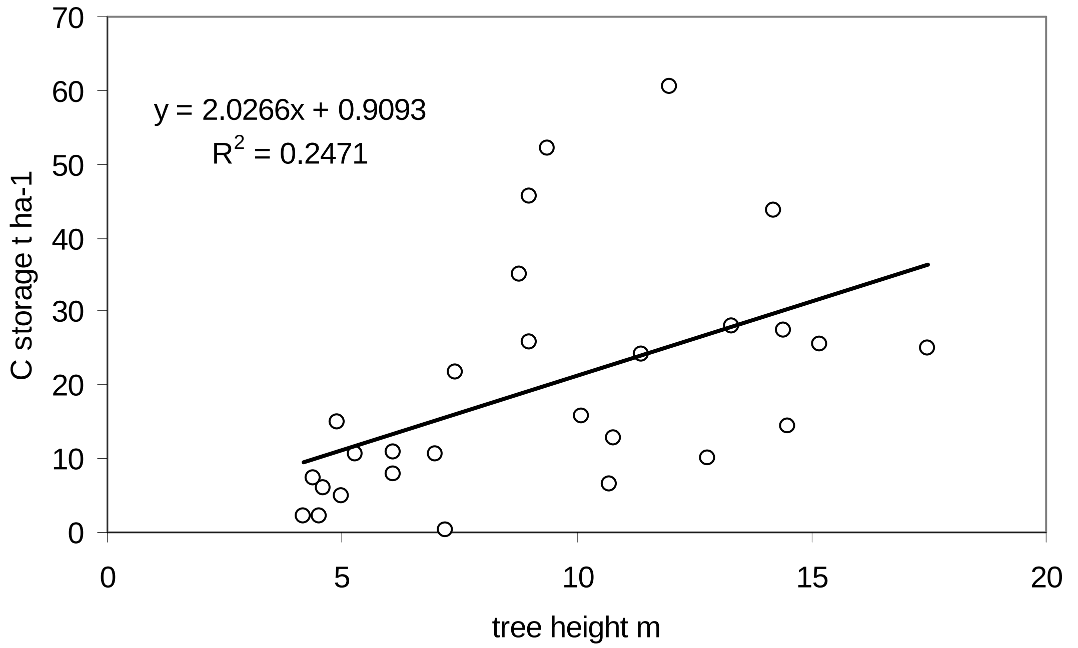

microbial respiration
microbial biomass
C storage


Casts or Earthworms
0.087
-0.025
Litter C/N
0.558
0.469
-0.507
-0.451
A layer
Casts or Earthworms
0.048
-0.169
Litter C/N
0.585
0.279
-0.374
-0.358
C content

Litter quality correspond with foliage



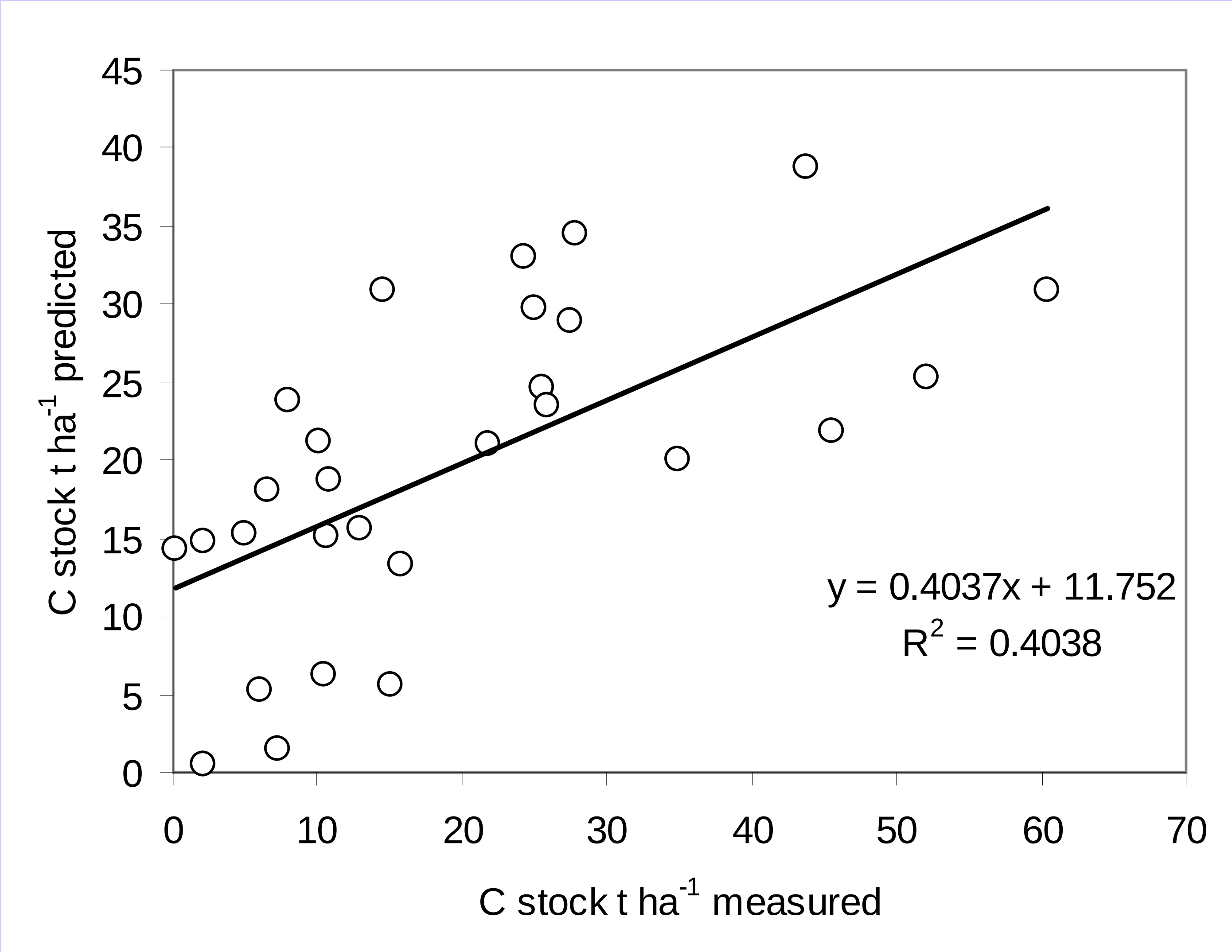




Both chlorophyll content
and tree height give significant correlation with C storage in soil.

Tree height and chlorophyll are not correlated

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



Conclusion

Soil fauna mainly earthworm activity is essential for accumulation of C in mineral layer.

Hardly decomposable litter (with higher C/N ration), accumulate more in soil when processed by soil fauna.

Trees producing easy decomposable litter support larger densities of soil macrofauna, than trees producing hardly decomposable litter, which result in higher bioturbation in the former ones.

Incorporation of OM in to mineral soil change other soil properties.

Leaf quality correspond with C storage as well, which bring some potential to estimate C storage from leaf quality using remote sensing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Thank you for your attention