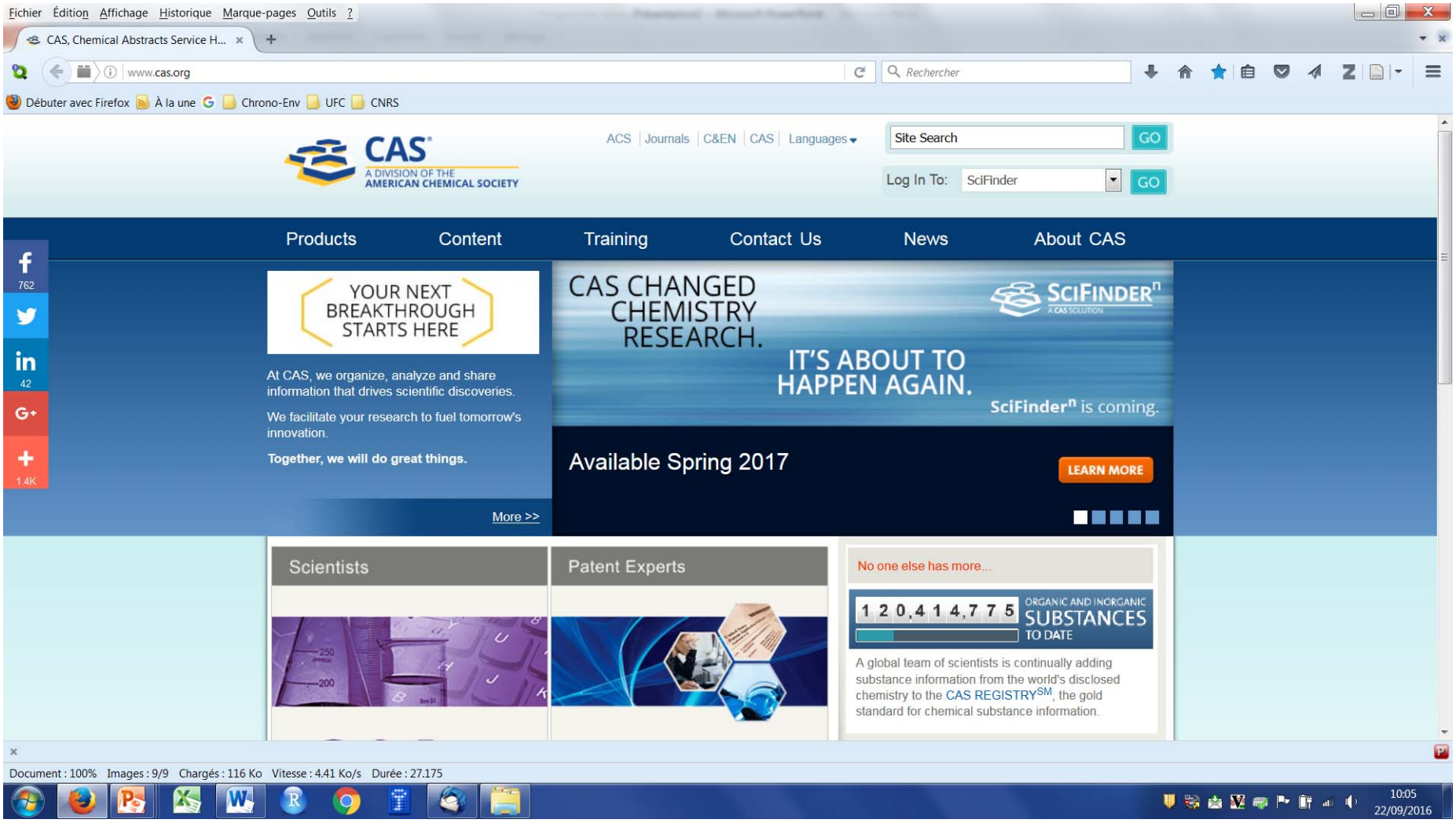
From ecotoxicology to stress ecology: pollutants and pathogens in terrestrial wildlife

Renaud Scheifler, Eve Afonso, Michaël Cœurdassier, Clémentine Fritsch, Patrick Giraudoux, Francis Raoul… et al.

www.naturfoto.cz

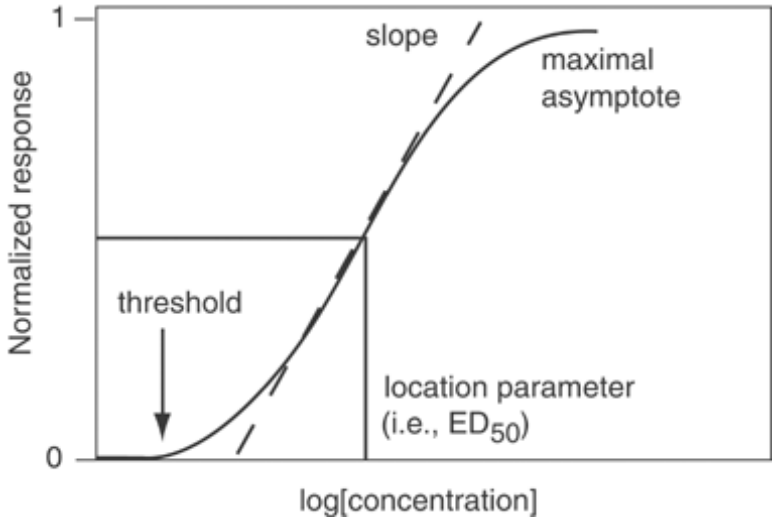
JOURNEES RONGEURS DU CBGP
26-27 septembre 2016

More than 120 millions of natural and anthropogenic substances



www.cas.org, consulté le 22 septembre 2016

Ecotoxicology: the laboratory-based paradigm
Standardized lab tests used to underpin decisions on registration of chemicals and derivation of environmental quality criteria (EQC)



Mono-specific dose-response curve

Strong social demand

van Straalen & van Gestel. 2008.
The Science of the Total Environment, 406: 479-483.

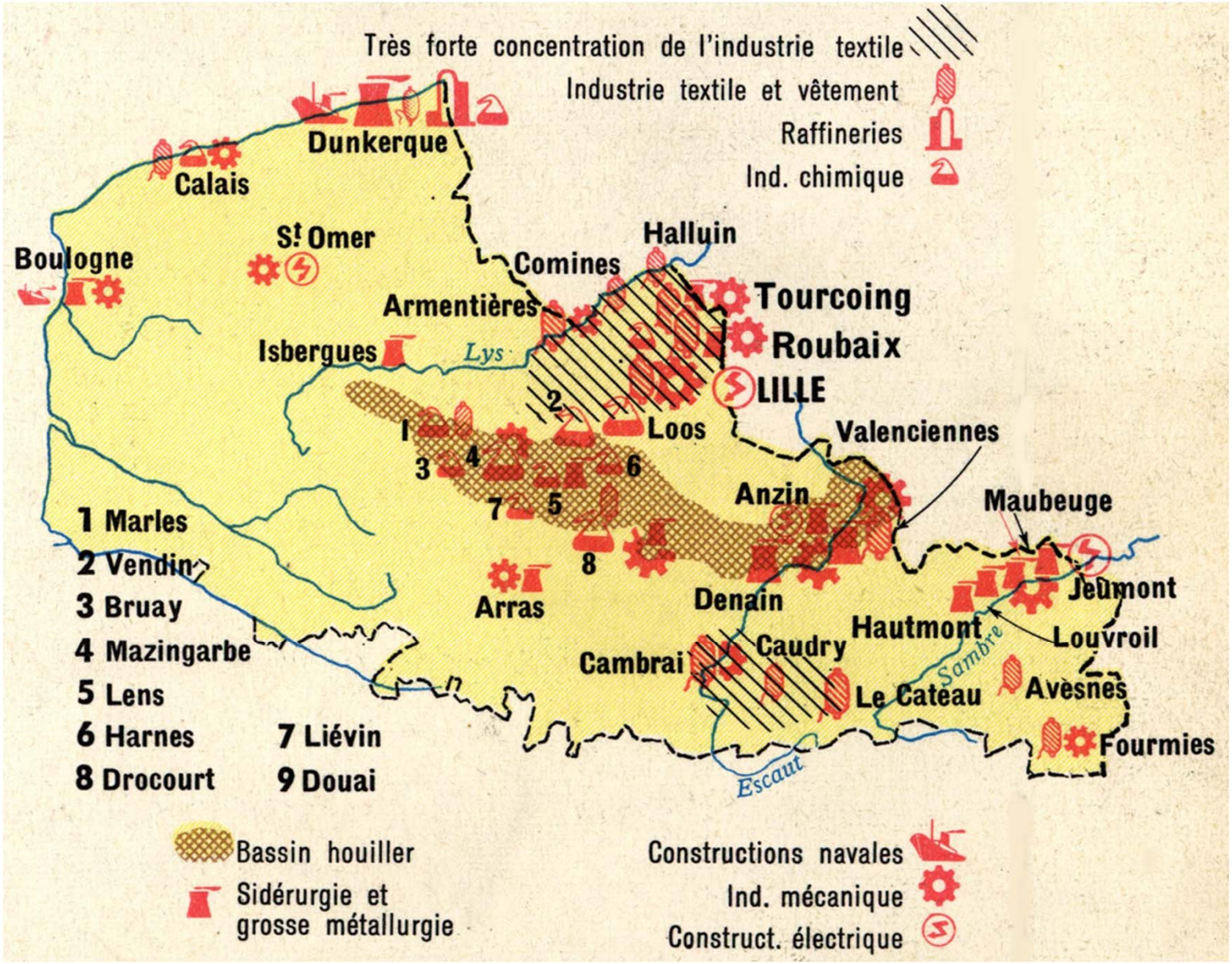
http://ec.europa.eu/enterprise/sectors/chemicals/reach/index_fr.htm

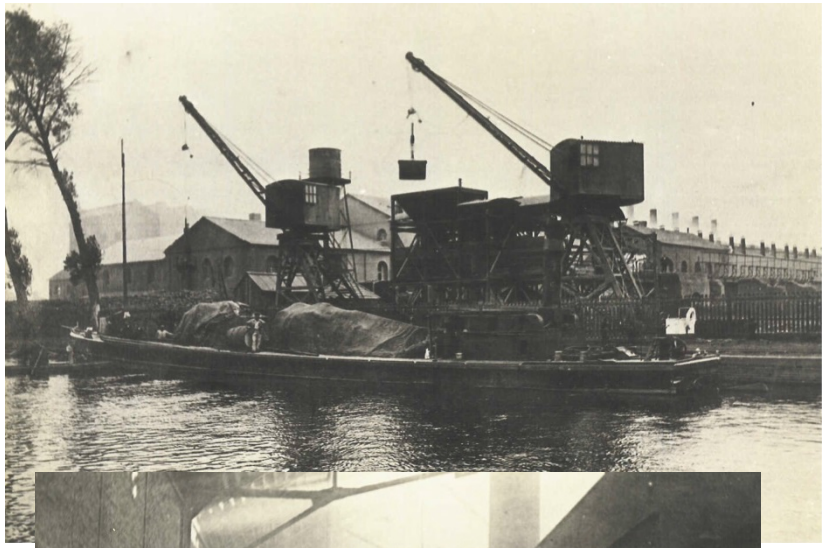
Ecotoxicology: a second framework is the study of toxic chemicals and ecological responses in the field

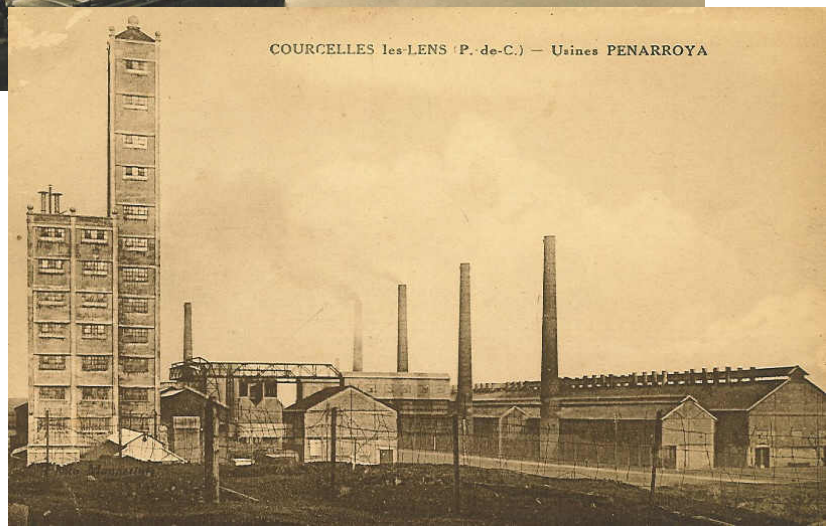
- Point source emitting a single chemical or a simple mixture of chemicals
- Gradient of pollution of the field
- Study of ecological variables as a function of distance from the source
- Hypothesis: high concentrations close to the source are associated to adverse effects
- Data may be used to derive critical concentrations in relation to effects in the field

van Straalen & van Gestel. 2008. *The Science of the Total Environment*, 406: 479-483.

Study site: Metaleurop Nord, a former Pb and Zn smelter







1894 : Installation à Noyelles-Godault d'une fonderie de Zn et d'un four à Pb par **Malfidano**

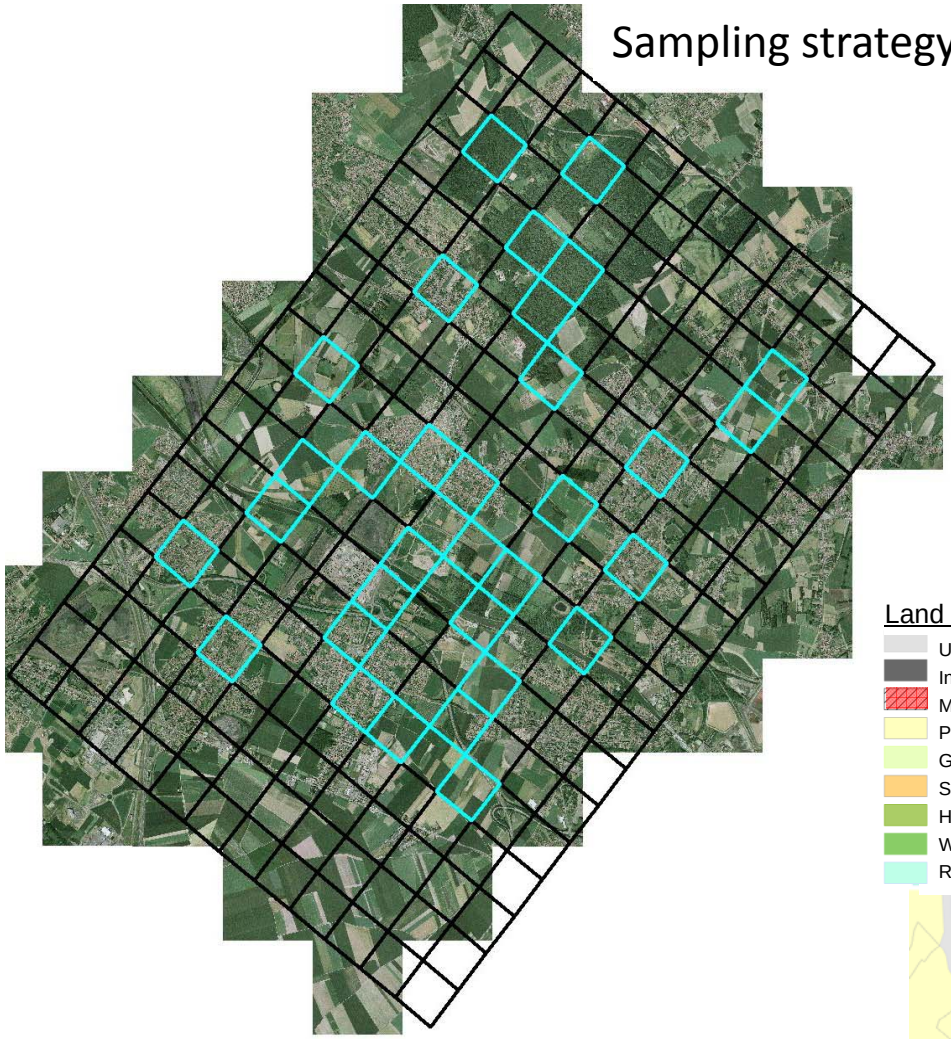
Destruction pendant la guerre 1914 - 1918

1920 : Reconstruction par la Société **Pennaroya**

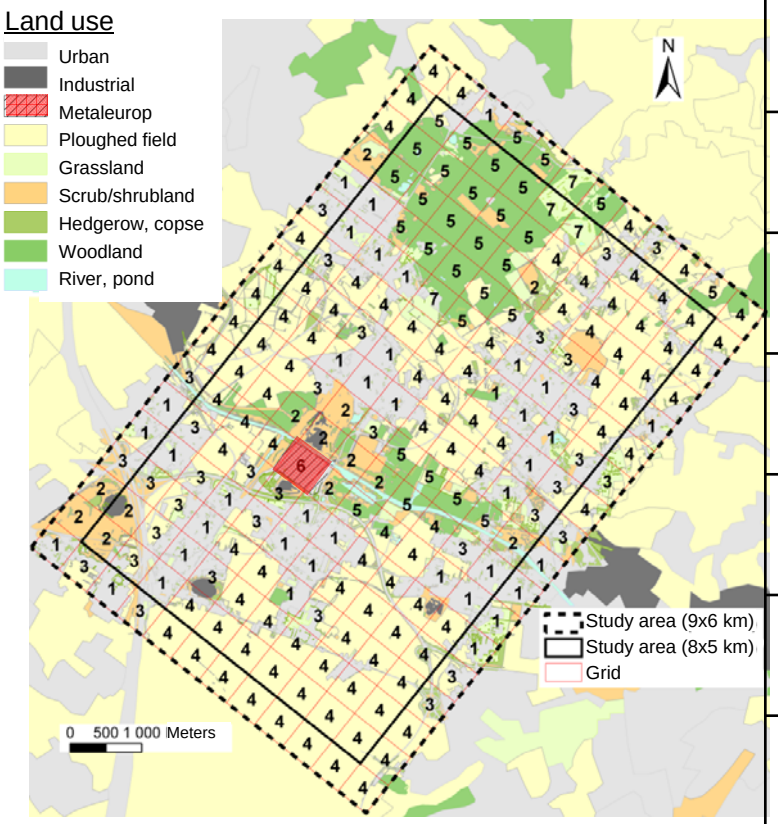
1988 : Création de Metaleurop SA et **Metaleurop Nord**

2003 : Fermeture de Metaleurop Nord

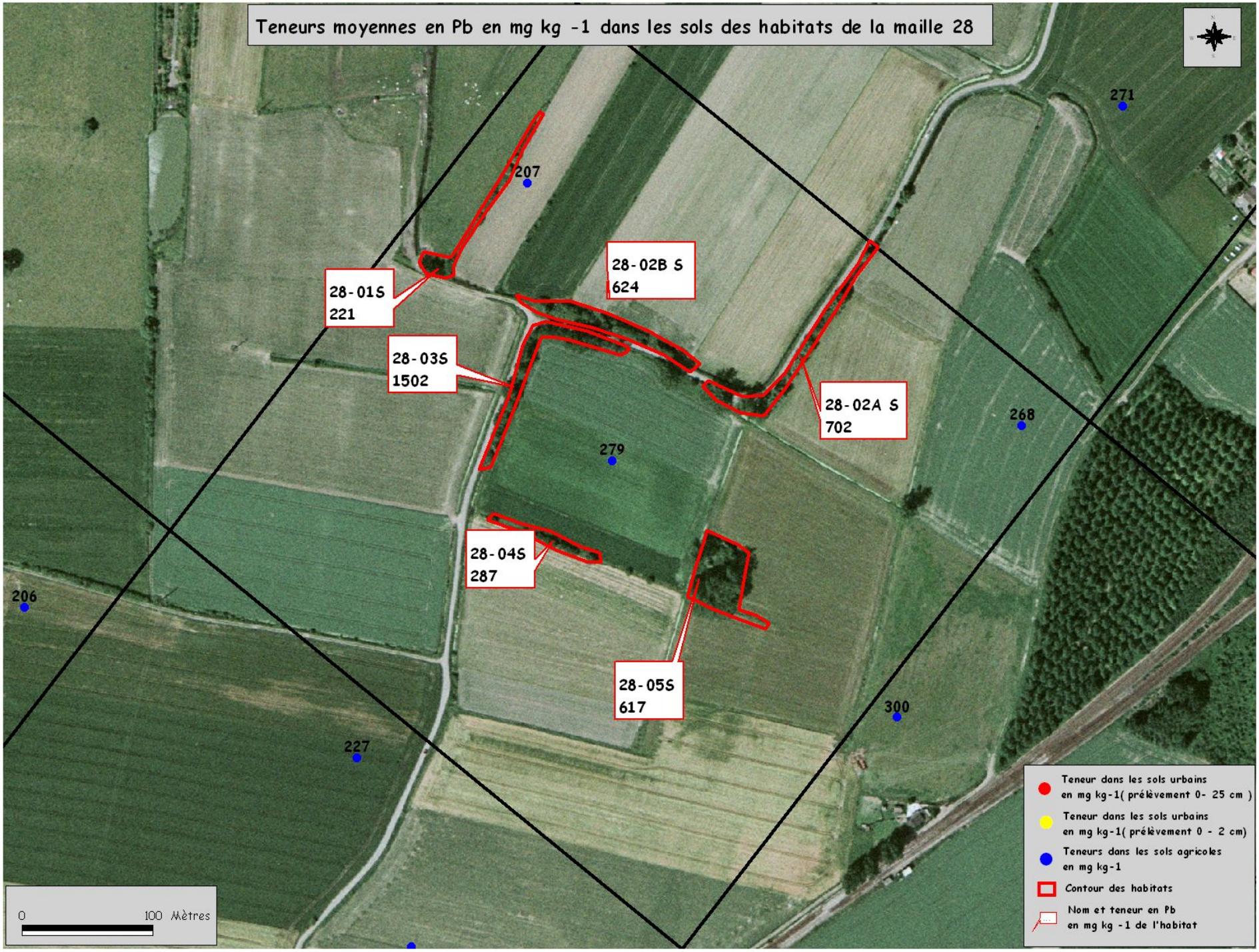
Sampling strategy: 30 squares of 25 ha along a pollution gradient in urban, agricultural, and forest areas



LANDSCAPE



1	Urban areas
2	Scrub/ shrublands
3	Mixed urban areas + other
4	Agricultural areas
5	Woodlands
6	Metaleurop
7	Mixed woodlands + grasslands


Teneurs moyennes en Pb en mg kg -1 dans les sols des habitats de la maille 28
28-01S
221
28-02B S
624
28-03S
1502
28-02A S
702
28-04S
287
28-05S
617
207
271
279
268
206
227
300
0
100 Mètres
Teneur dans les sols urbains
en mg kg-1(prélèvement 0- 25 cm)
Teneur dans les sols urbains
en mg kg-1(prélèvement 0 - 2 cm)
Teneurs dans les sols agricoles
en mg kg-1
Contour des habitats
Nom et teneur en Pb
en mg kg -1 de l'habitat


Teneurs moyennes en Pb en mg kg -1 dans les sols des habitats de la maille 96
96-02S
1398
96-03S
1144
96-04S
1327
96-01S
301
96-05S
642
1100
1972
1380
1180
821
919
821
824
50
0
100 Mètres
Teneur dans les sols urbains
en mg kg-1(prélèvement 0- 25 cm)
Teneur dans les sols urbains
en mg kg-1(prélèvement 0 - 2 cm)
Teneurs dans les sols agricoles
en mg kg-1
Contour des habitats
Nom et teneur en Pb
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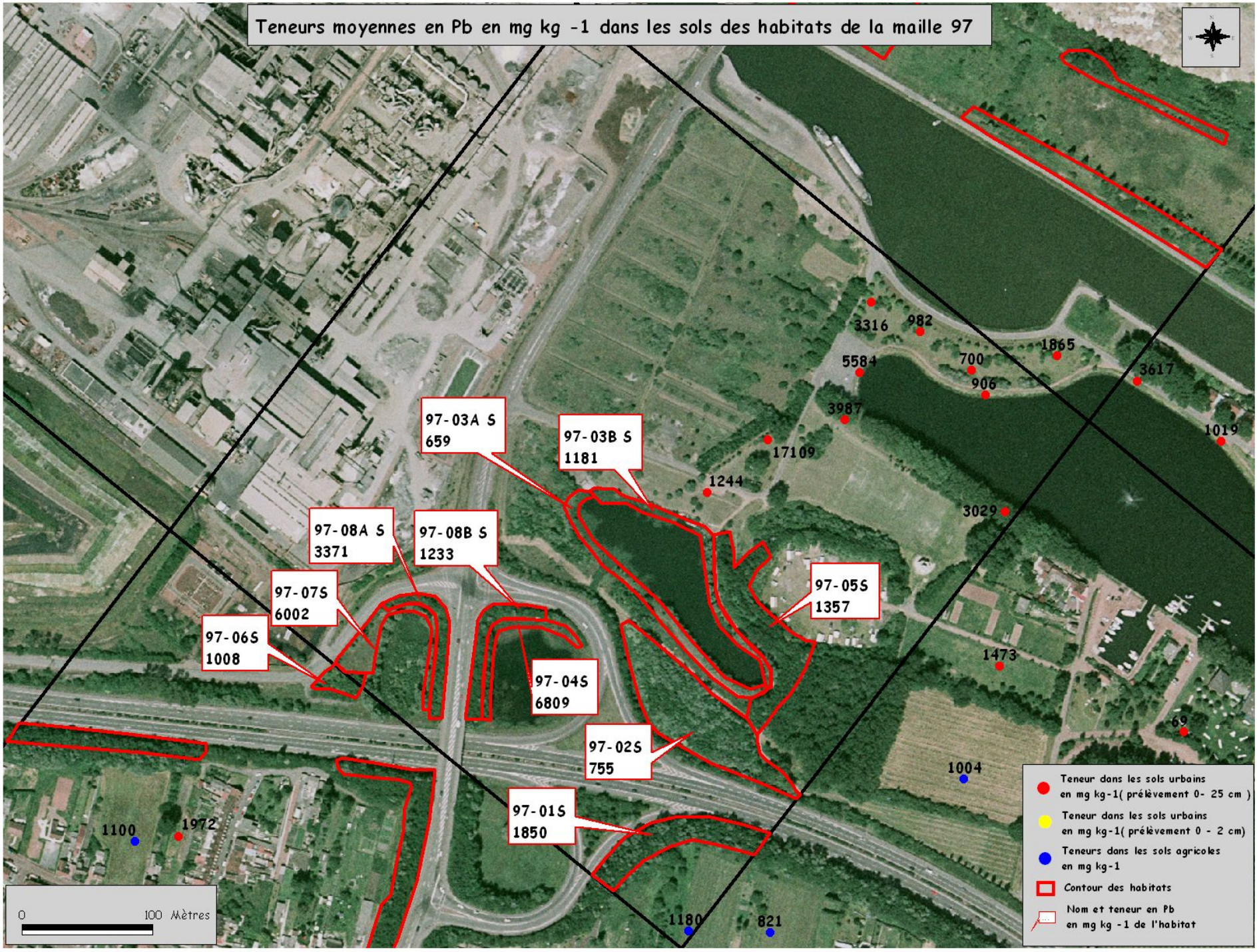
Teneurs moyennes en Pb en mg kg -1 dans les sols des habitats de la maille 97
97-03A S
659
97-03B S
1181
97-08A S
3371
97-08B S
1233
97-07S
6002
97-06S
1008
97-04S
6809
97-02S
755
97-01S
1850
97-05S
1357
3316
982
1865
5584
700
906
3617
3987
1019
17109
1244
3029
1473
69
1004
1100
1972
1180
821
0
100 Mètres
Teneur dans les sols urbains
en mg kg-1(prélèvement 0- 25 cm)
Teneur dans les sols urbains
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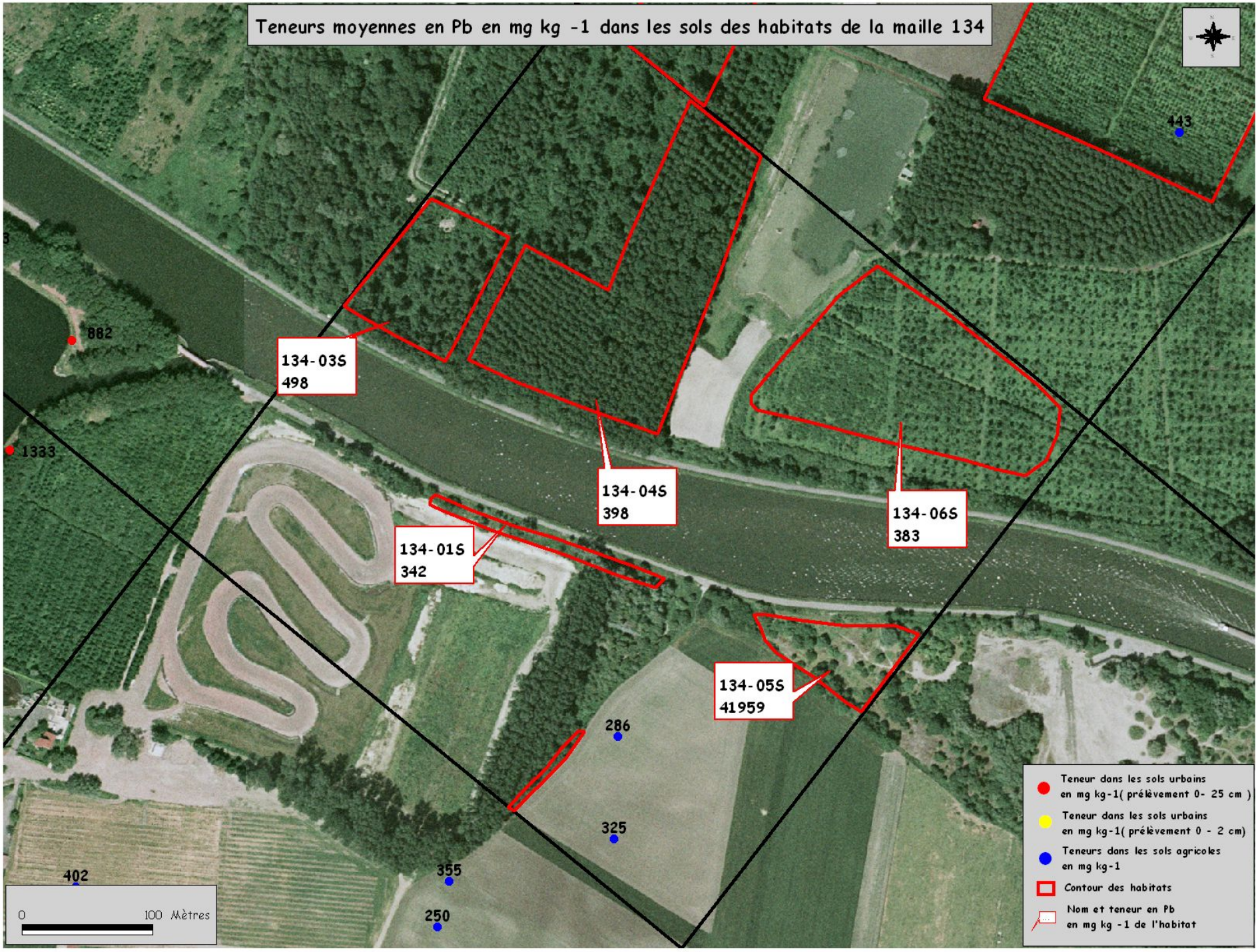
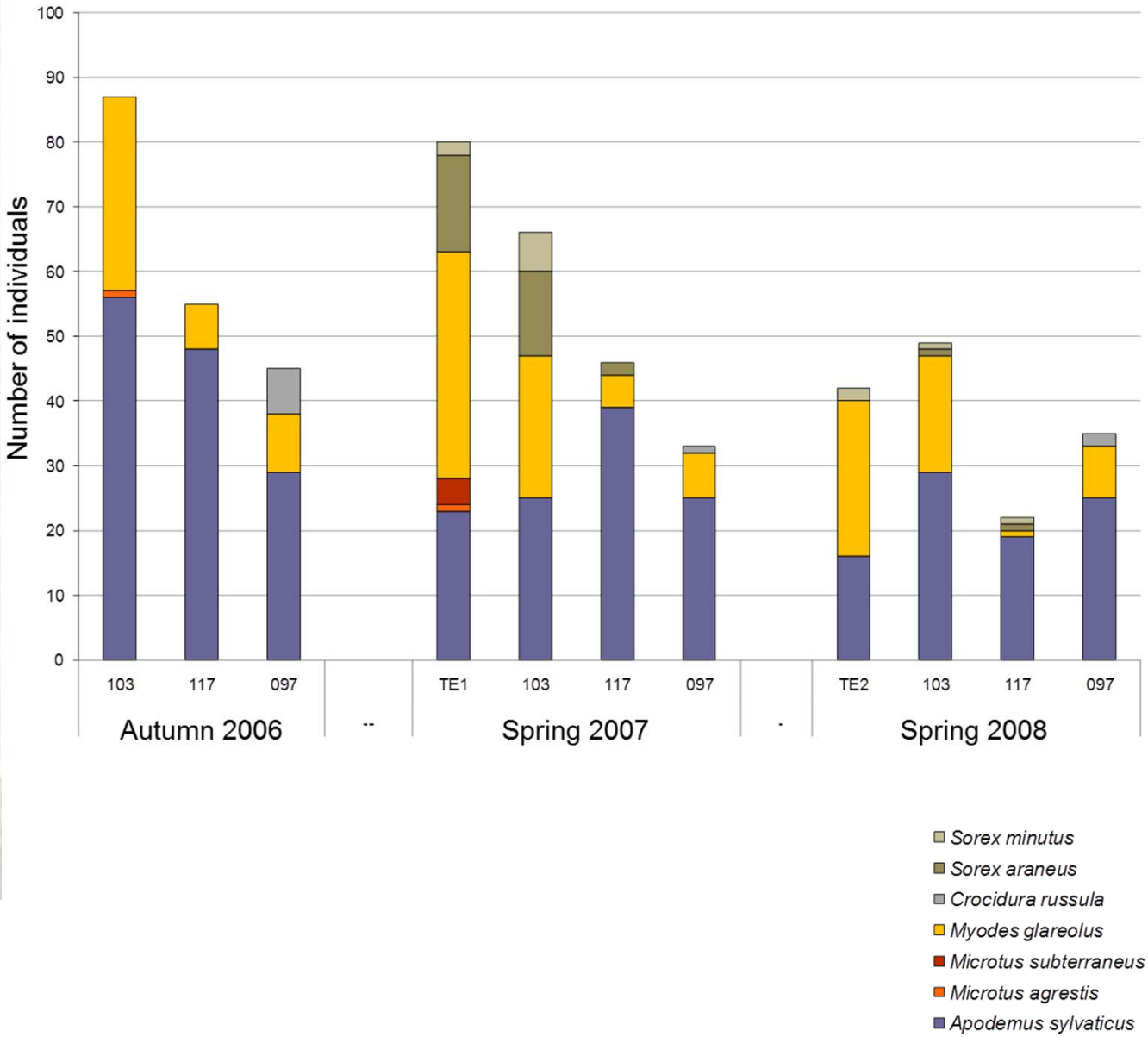
Teneurs dans les sols agricoles
en mg kg-1
Contour des habitats
Nom et teneur en Pb
en mg kg -1 de l'habitat


Teneurs moyennes en Pb en mg kg -1 dans les sols des habitats de la maille 134
443
882
1333
134-03S
498
134-04S
398
134-06S
383
134-01S
342
134-05S
41959
286
325
355
402
250
0
100 Mètres
Teneur dans les sols urbains
en mg kg-1(prélèvement 0- 25 cm)
Teneur dans les sols urbains
en mg kg-1(prélèvement 0 - 2 cm)
Teneurs dans les sols agricoles
en mg kg-1
Contour des habitats
Nom et teneur en Pb
en mg kg -1 de l'habitat

11 small mammal species on the site…
with complex interannual variations

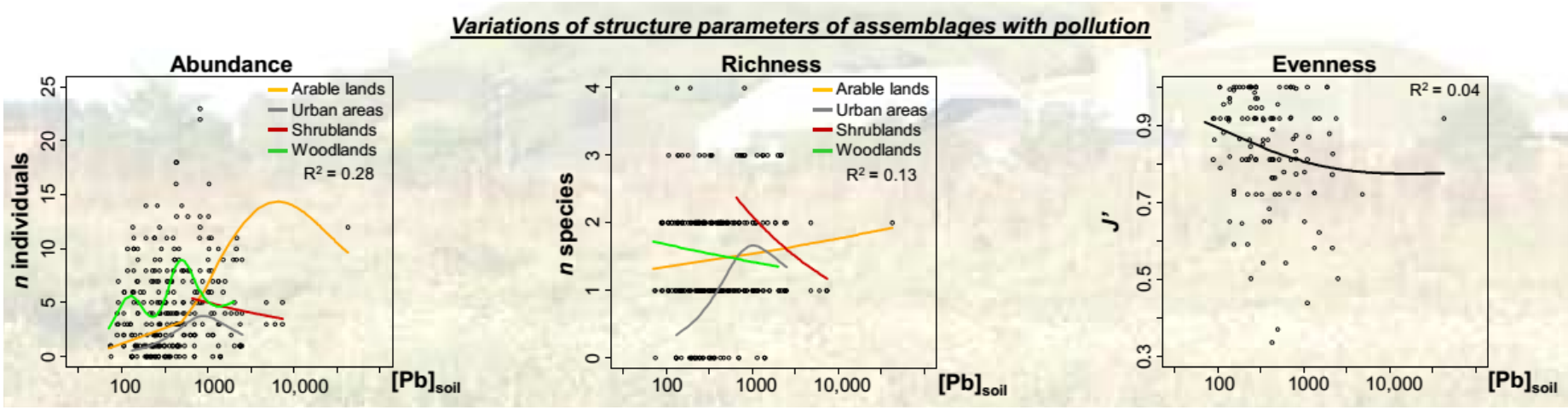
Number of individuals captured (n) and capture success (% captures: n/100 trap-nights)

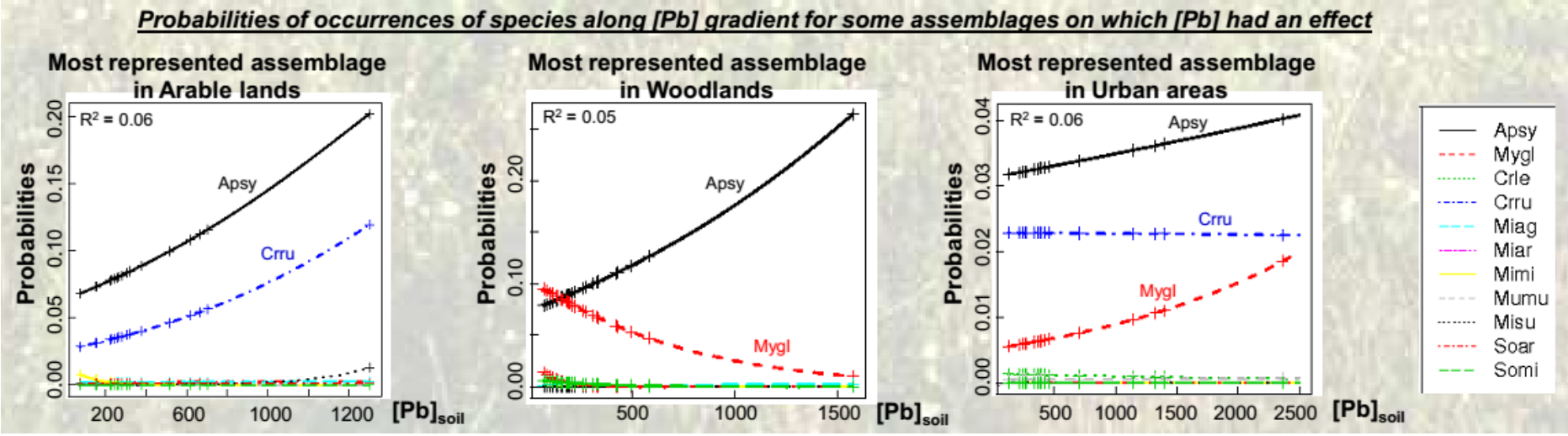
	n	Capture success
 *Apodemus sylvaticus* (Apsy)	859	9.94
 *Micromys minutus* (Mimi)	5	0.06
 *Mus musculus* (Mumu)	5	0.06
 *Myodes glareolus* (Mygl)	254	2.94
 *Microtus agrestis* (Miag)	9	0.10
 *Microtus arvalis* (Miar)	9	0.10
 *Microtus subterraneus* (Misu)	2	0.02
 *Crocidura leucodon* (Crle)	12	0.14
 *Crocidura russula* (Crru)	164	1.90
 *Sorex araneus* (Soac)	11	0.13
 *Sorex minutus* (Somi)	8	0.09



Fritsch, 2010

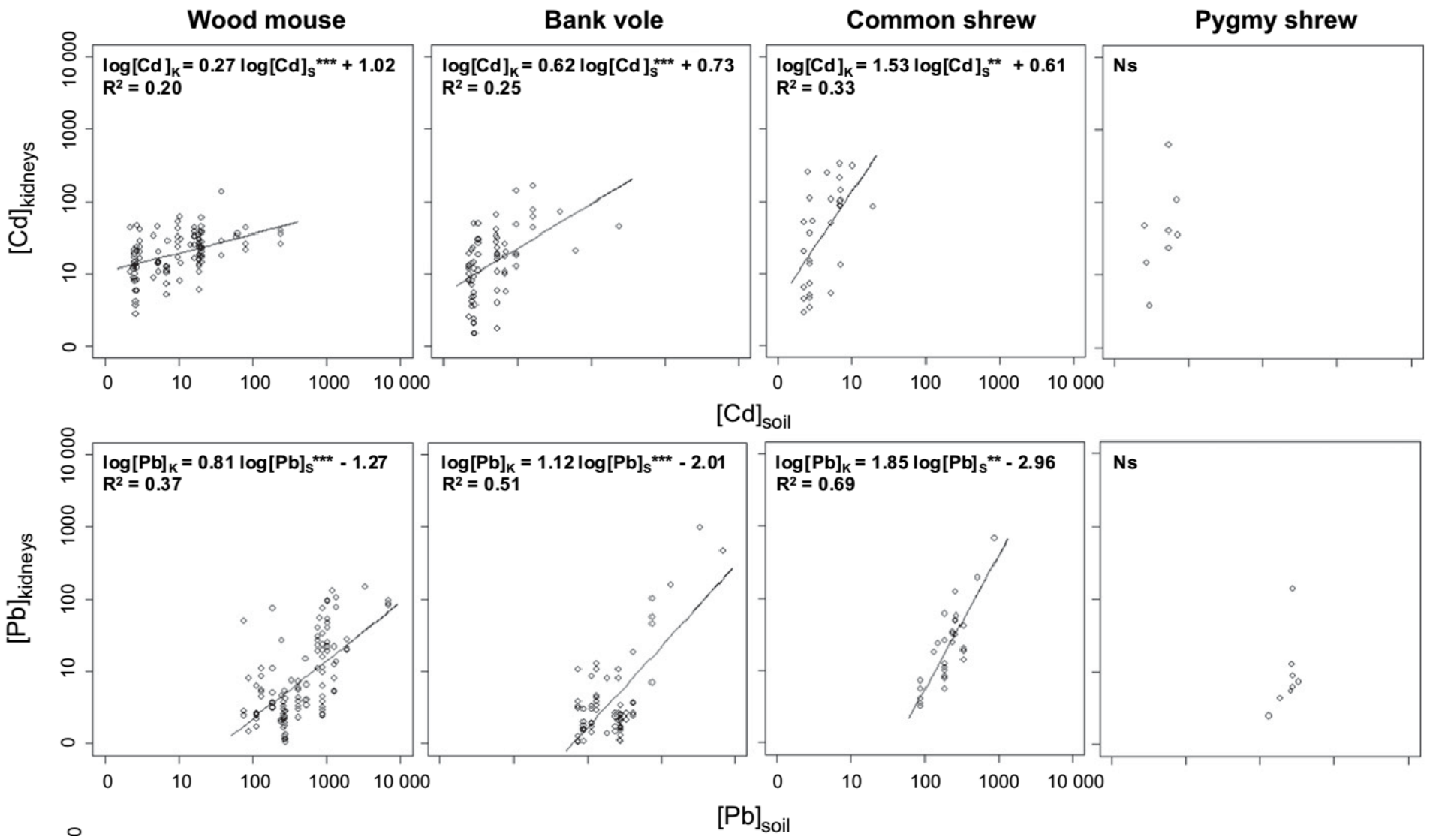
The dominance of the wood mouse increases along the pollution gradient





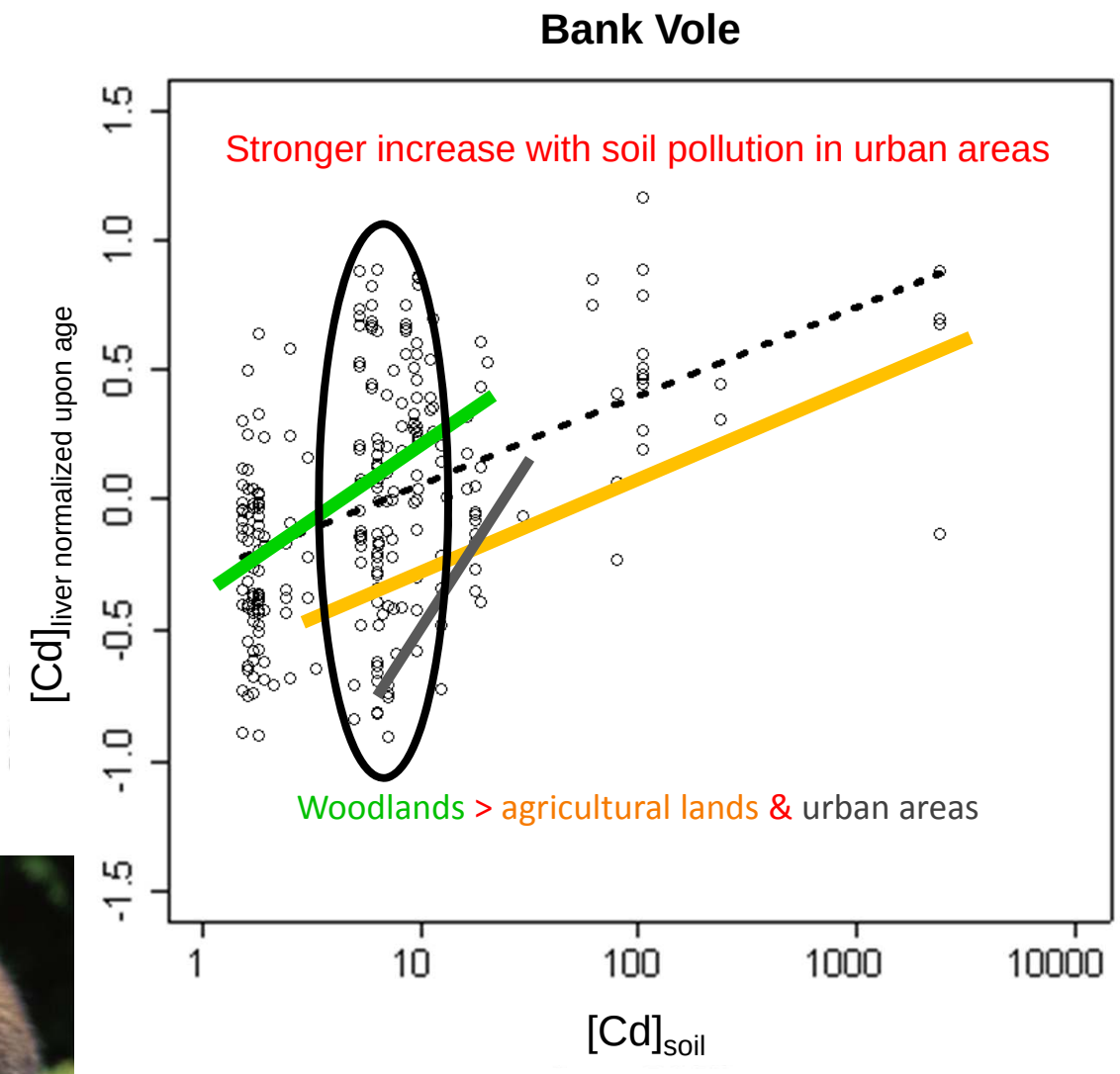
Fritsch, in prep.

Accumulation of trace metals varies according to species



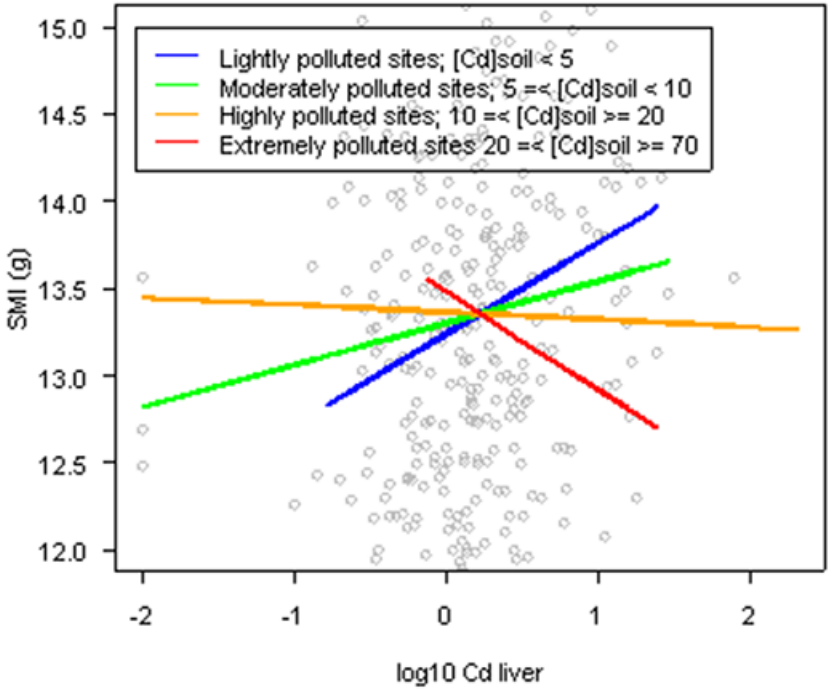
Fritsch et al. 2010. *Environmental Pollution*, 158: 827-840.

Accumulation of trace metals varies according to landscape

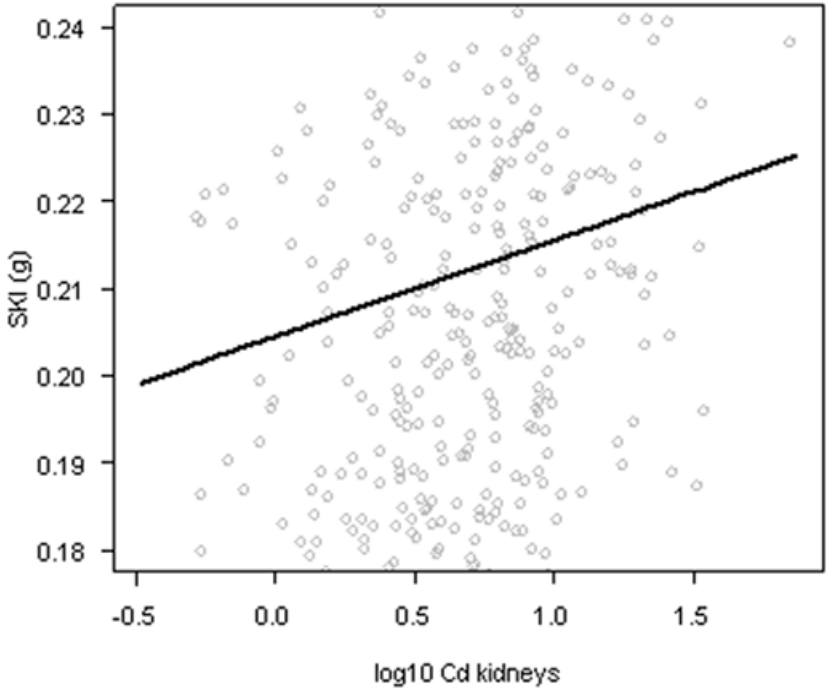


Fritsch et al. 2011. *PLoS ONE*, 6(5): e20682.

Body condition decreases at high to very high concentrations in the tissues

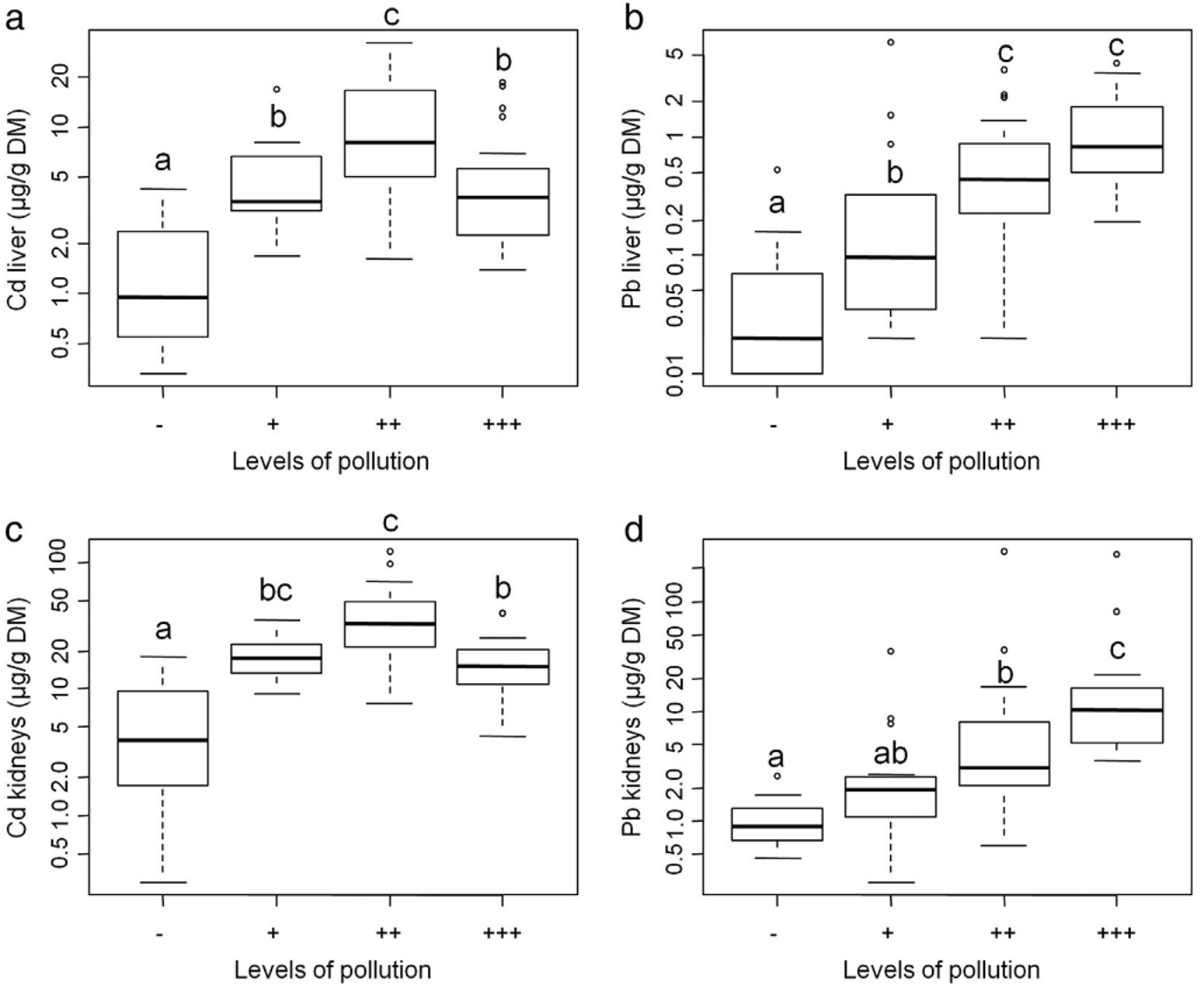


The increase of the kidney index suggests histopathology



Tête et al. 2013. *PLoS ONE*, 8(6): e66399.

Over time (2006-2012), accumulation pattern changed: [Pb] increase along the pollution gradient while [Cd] show a bell-shaped curve



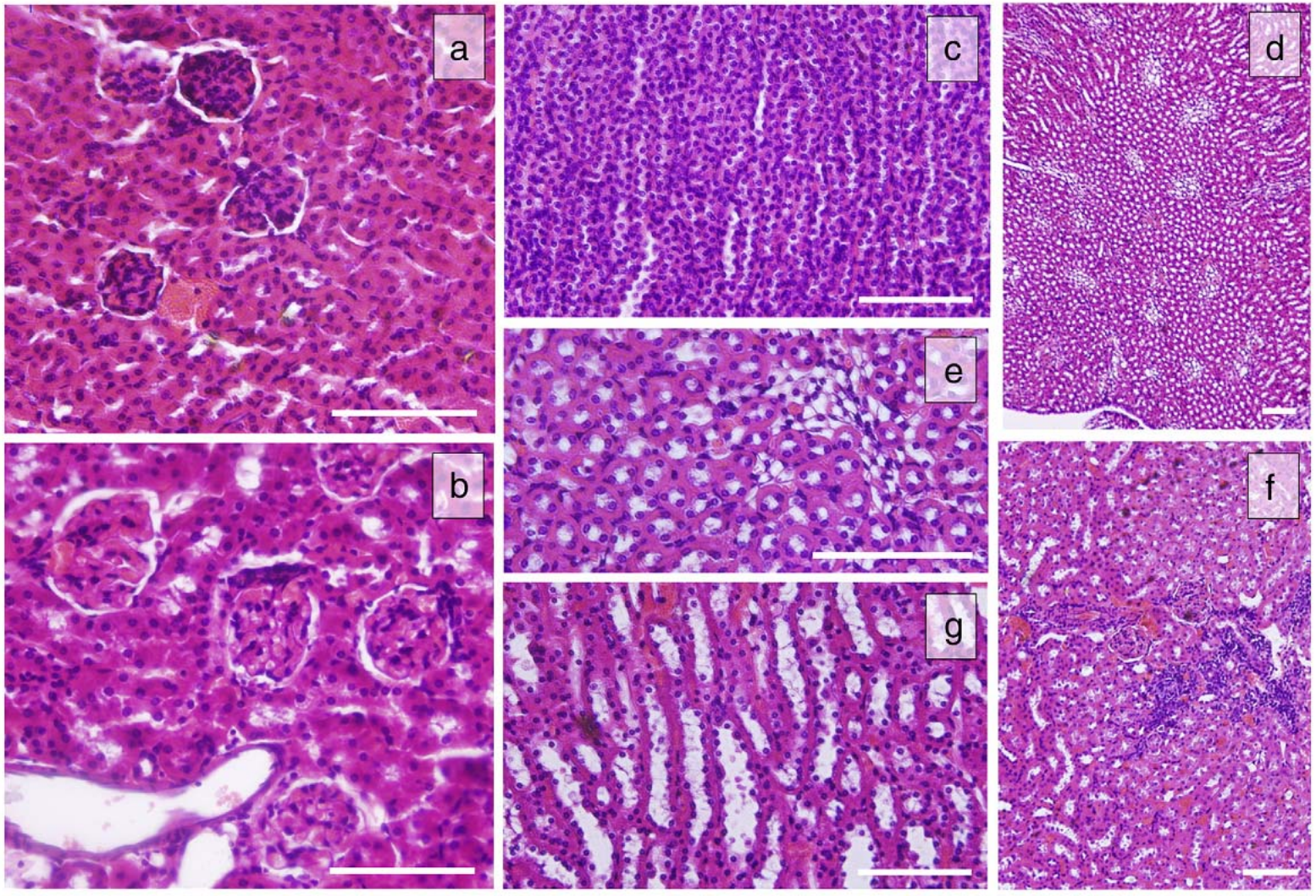
Tête et al. 2014. *The Science of the Total Environment*, 481: 167-177.

Histological alterations were observed in the kidneys

Glomerular hyperplasia (b)

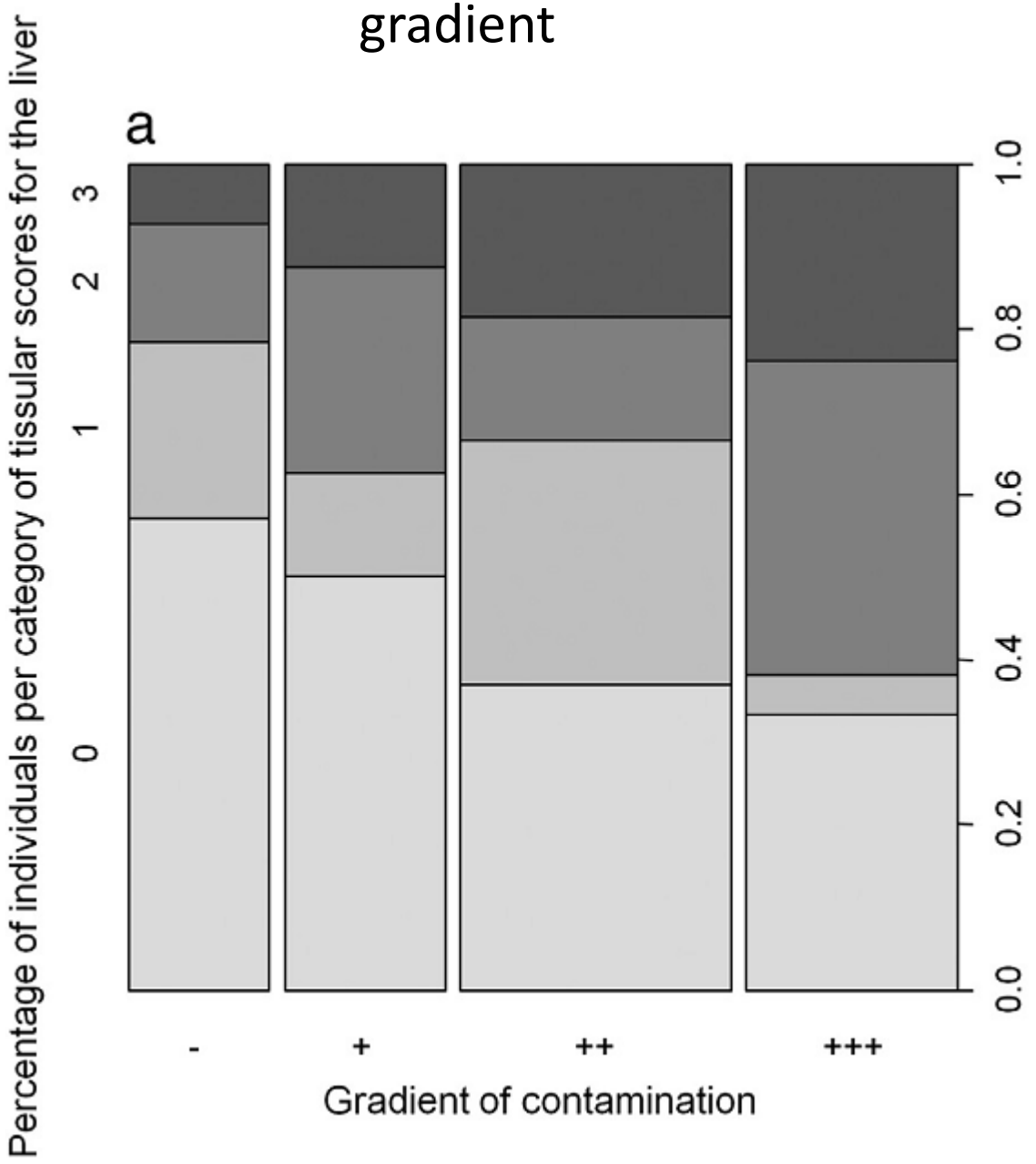
Tubular necrosis (d)

Inflammation and lymphocyte infiltration (f)



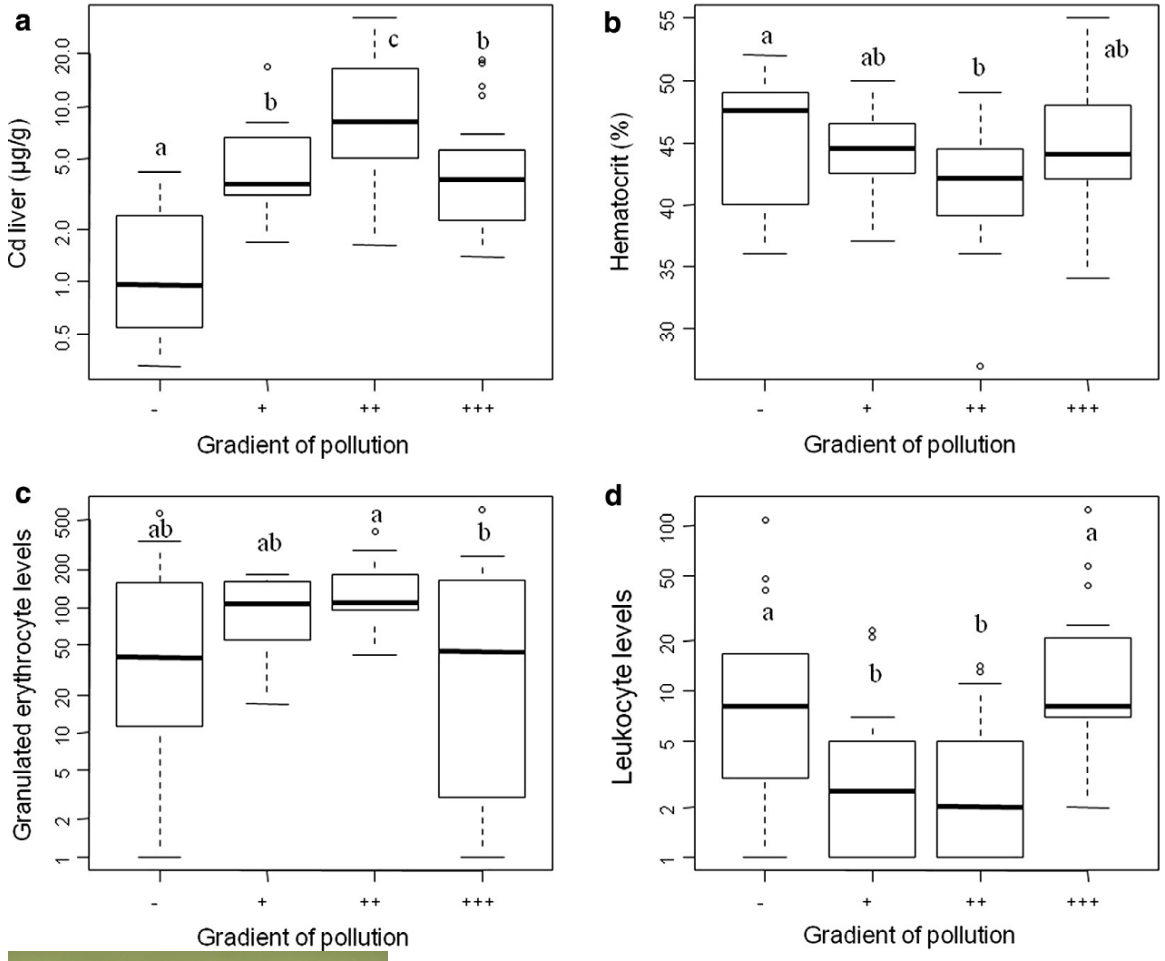
Tête et al. 2014. *The Science of the Total Environment*, 481: 167-177.

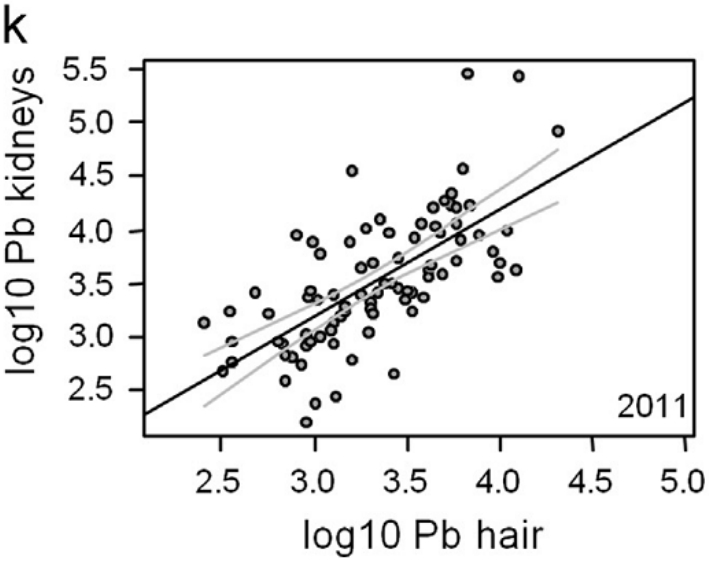
The severity of histological alterations increases along the pollution gradient



Tête et al. 2014. *The Science of the Total Environment*, 481: 167-177.

Non-invasive methods have been developed for both accumulation and effects

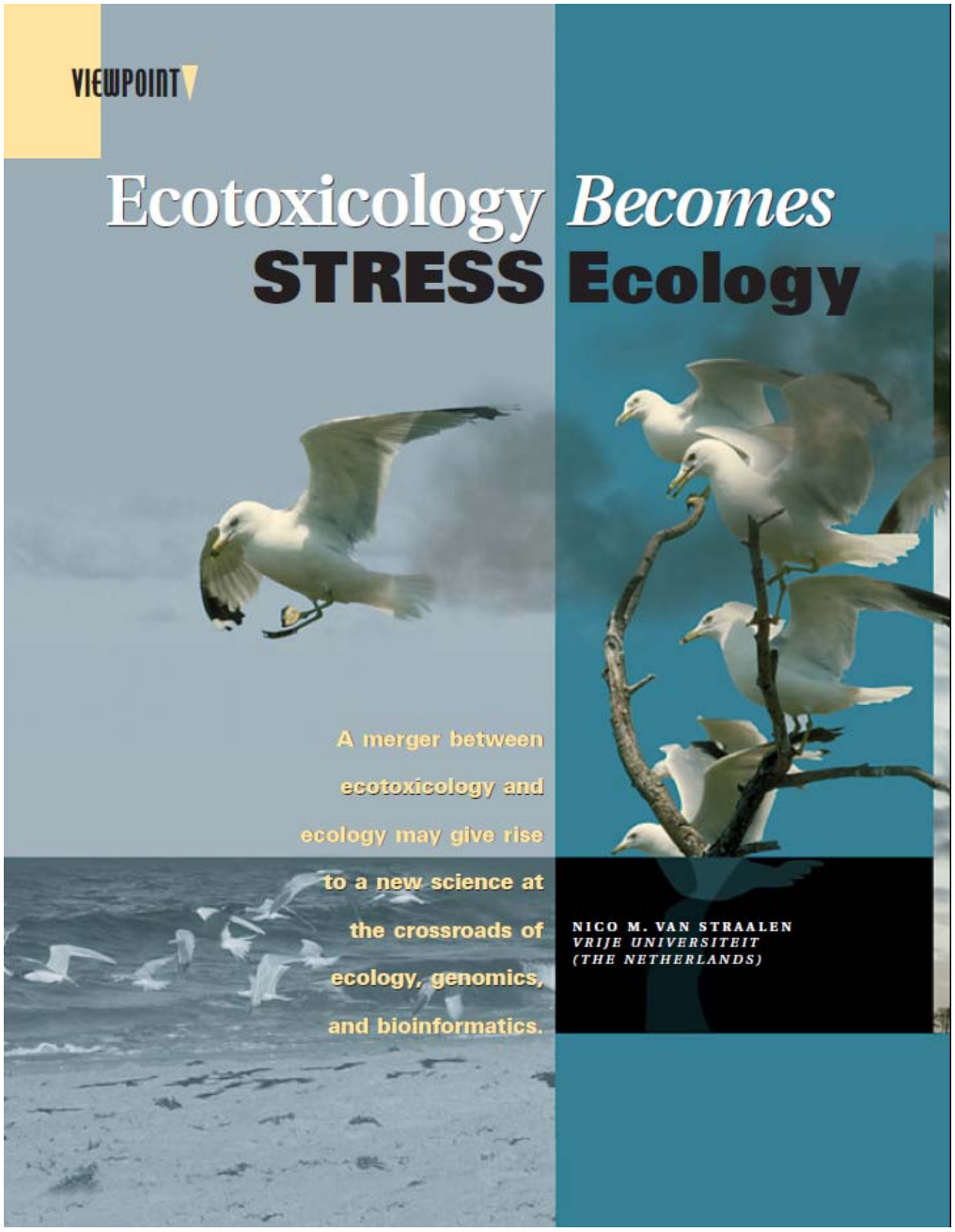




Tête et al. 2015. *Chemosphere*, 138: 940-946.

Tête et al. 2014. *Ecotoxicology and Environmental Safety*, 108: 233-241.

How to make ecotoxicology moving towards stress ecology?

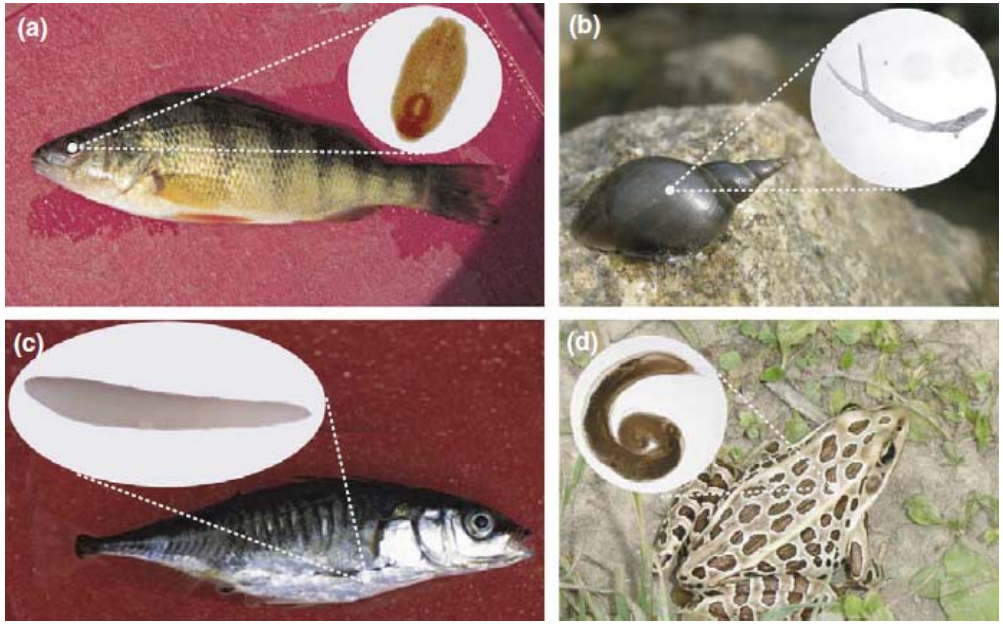


Van Straalen. 2003. *Environmental Science & Technology*, 37: 324A-330A.

Interactions between parasites and pesticides have additive or synergistic deleterious effects

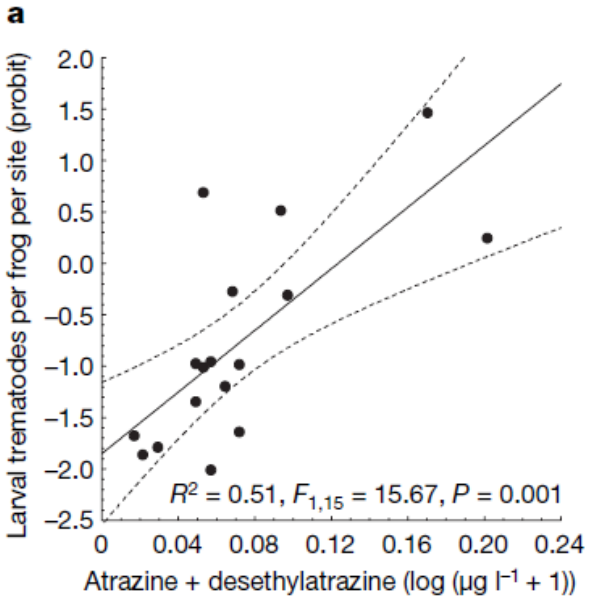
Table I. Effects of predation, parasitism and pesticide combined exposures on life history characteristics of *Daphnia magna*[a,b]

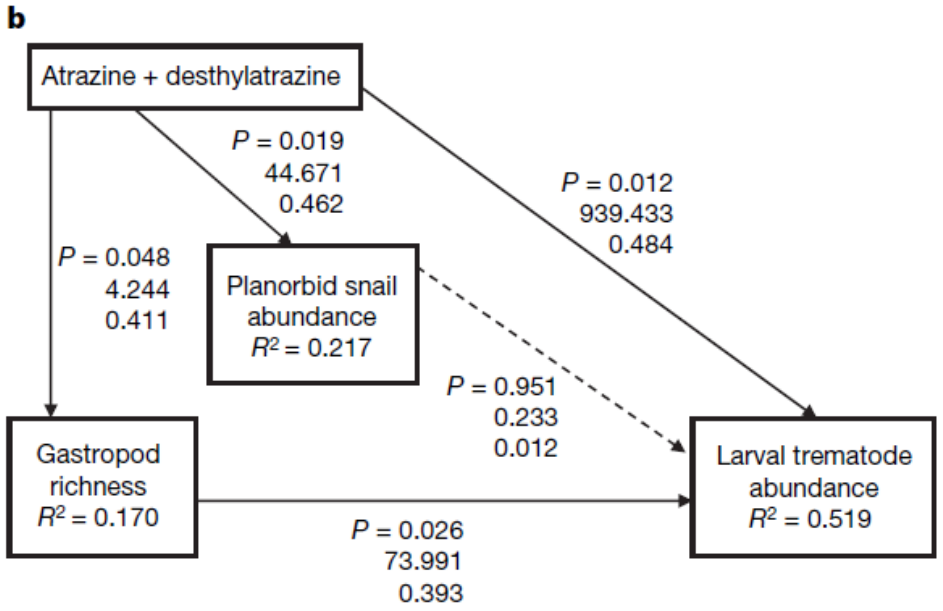
Life history trait	Stressors	Observation	Effect
Survival	pred + par	No change	None
	par + pest	Decrease	Synergistic
	pred + par + pest	Decrease	Synergistic
Castration rate	pred + par	Increase	Additive
	par + pest	Increase	Additive
	pred + par + pest	Large increase	Synergistic
Age at maturity	pred + par	Increase	Additive
	par + pest	Increase	Additive
	pred + par + pest	Large increase	Additive
Number in brood	pred + par	Decrease	Antagonistic
Population growth	pred + par	Decrease	Synergistic
	par + pest	Decrease	Synergistic
	pred + par + pest	Large decrease	Synergistic

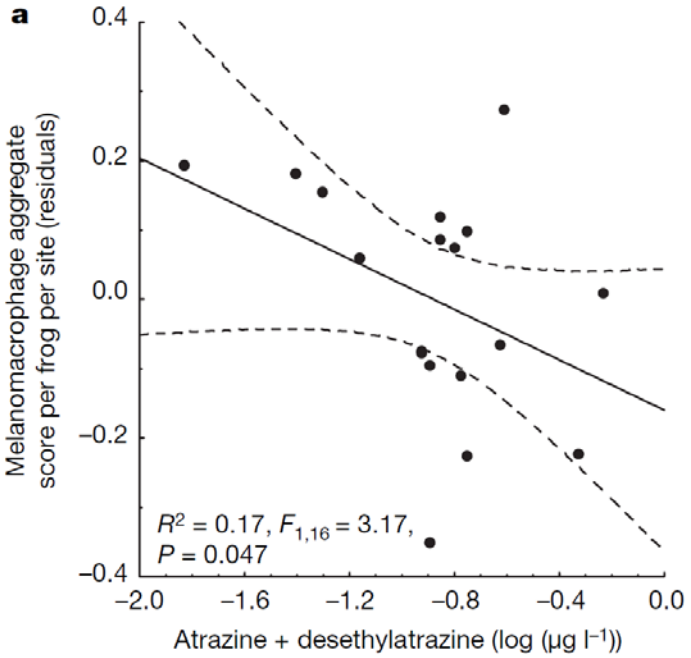


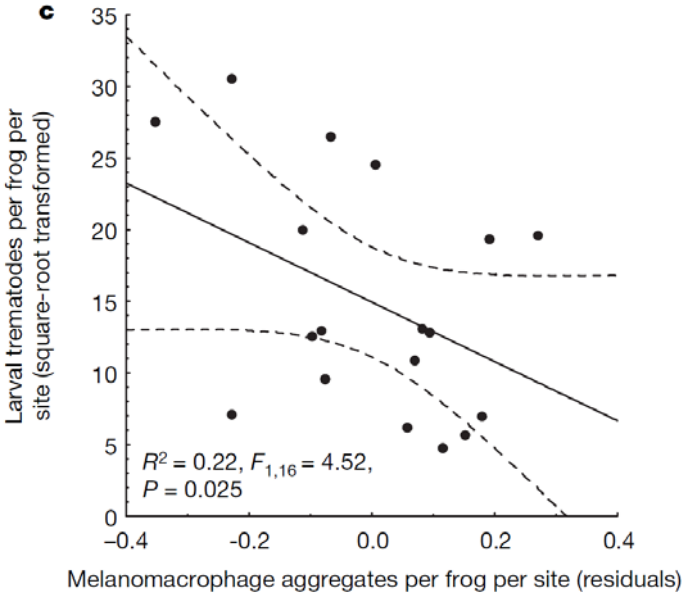
Marcogliese & Petrock. 2011. *Trends in Parasitology*, 27: 123-130.

Atrazine was the best predictor of the abundance of larval trematodes in the declining northern leopard frog *Rana pipiens*

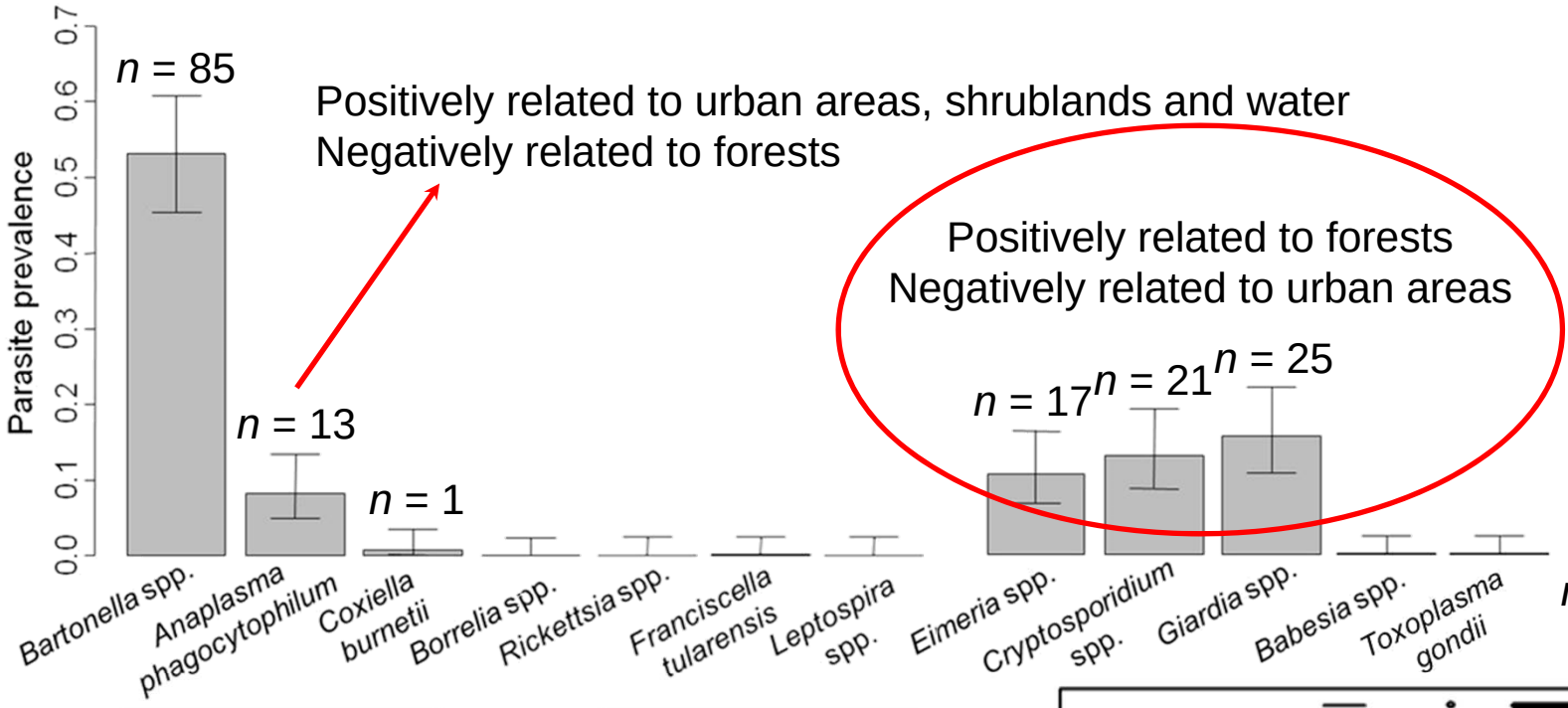




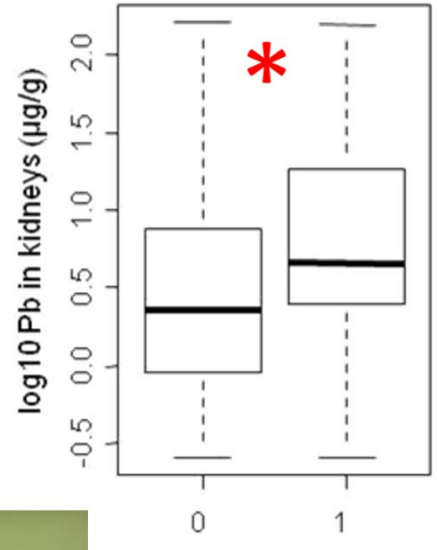




Rohr et al. 2008. *Nature*, 455: 1235-1240.

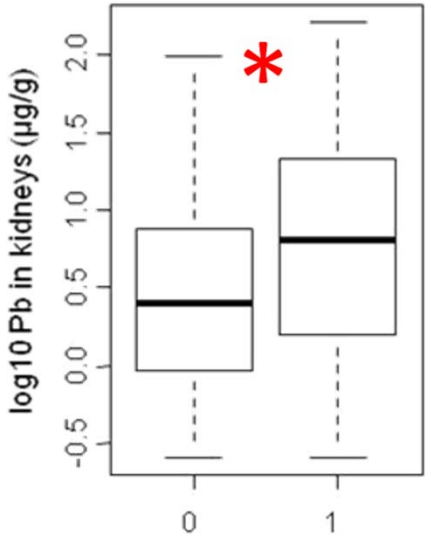


n = 162



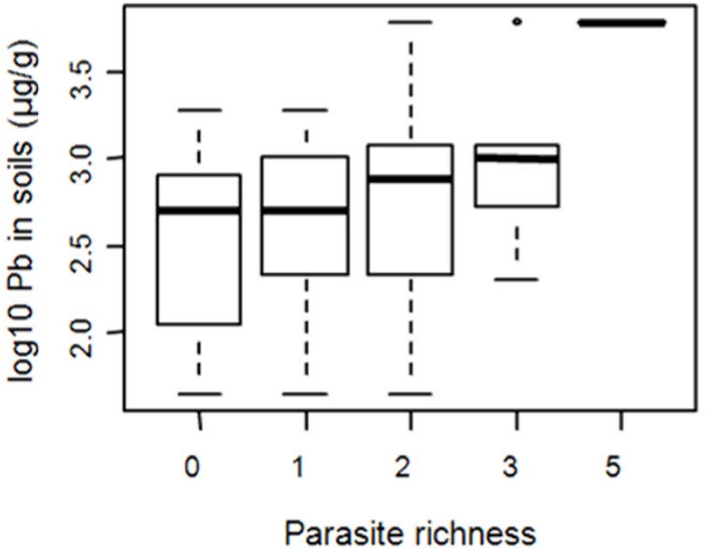
c *Giardia* spp.

(Mann-Whitney test
$U = 823$, $p = 0.029$)



d *Eimeria* spp.

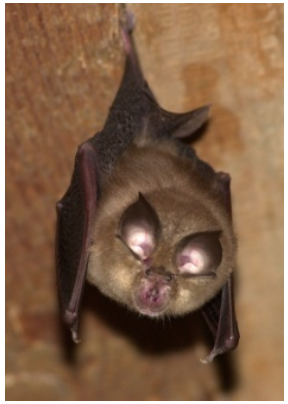
(Mann-Whitney test
$U = 1204$, $p = 0.023$)

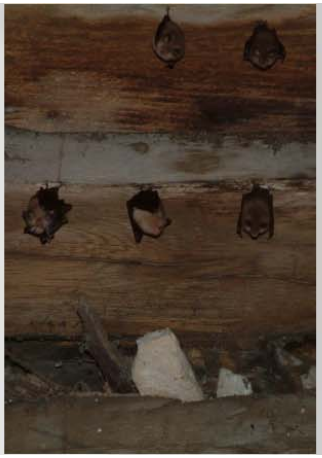
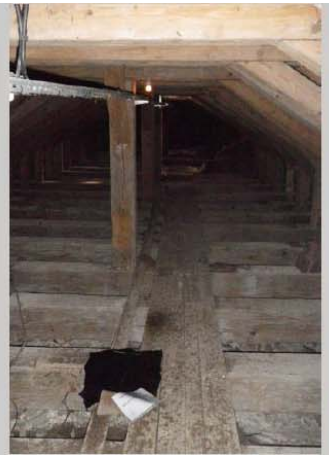


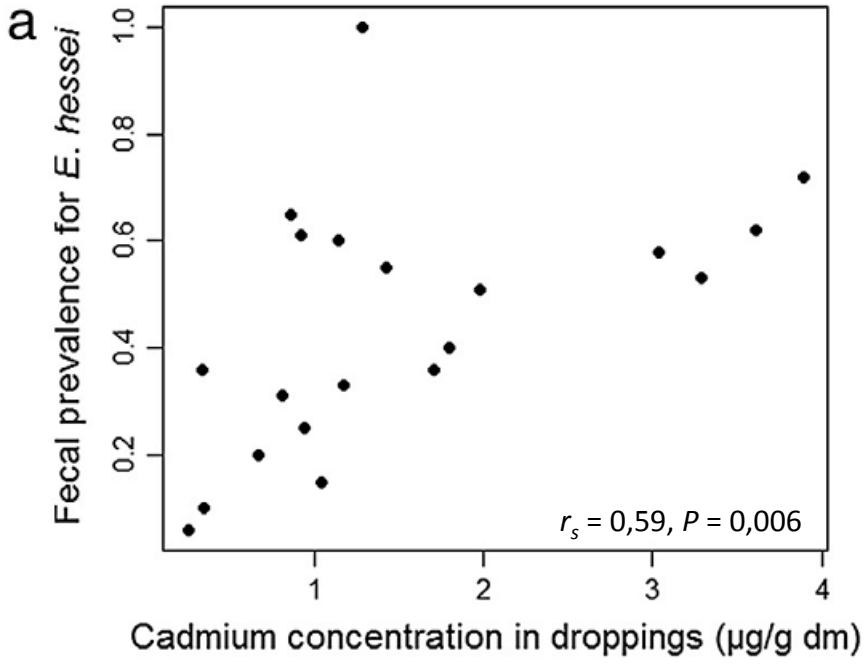
Spearman's rank correlation
For Cd_{soil} : r_s=0.20, p = 0.012
For Pb_{soil} : r_s =0.21, p = 0.009

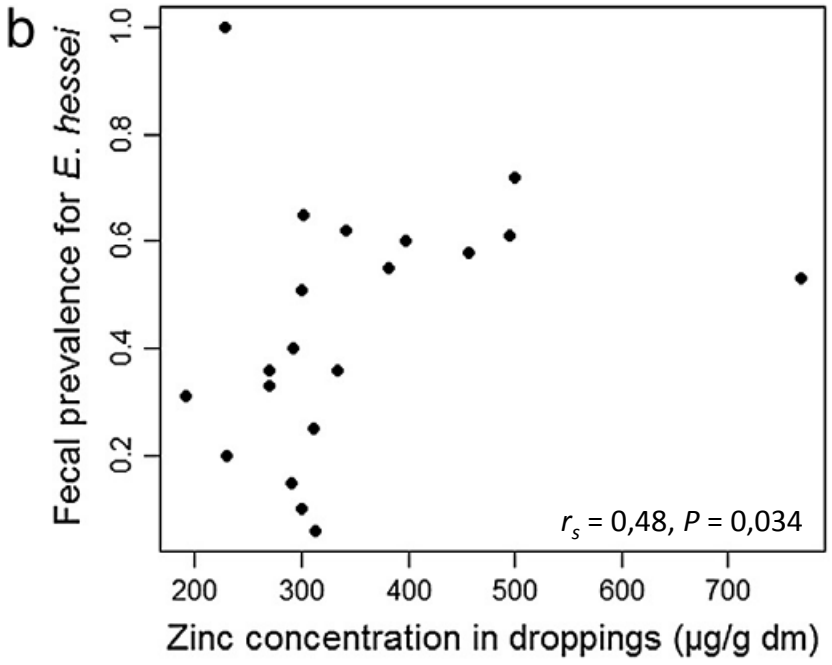
Tête et al. *In prep*.

Eimeria hessei prevalence is related to metal concentrations in the lesser horseshoe bat (*Rhinolophus hipposideros*) droppings



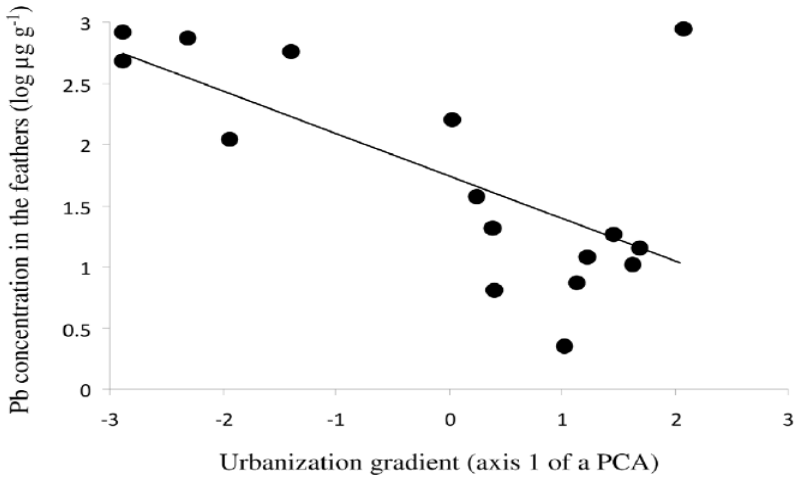




Afonso et al. 2016. *Global Ecology and Conservation*, 8: 123-137.

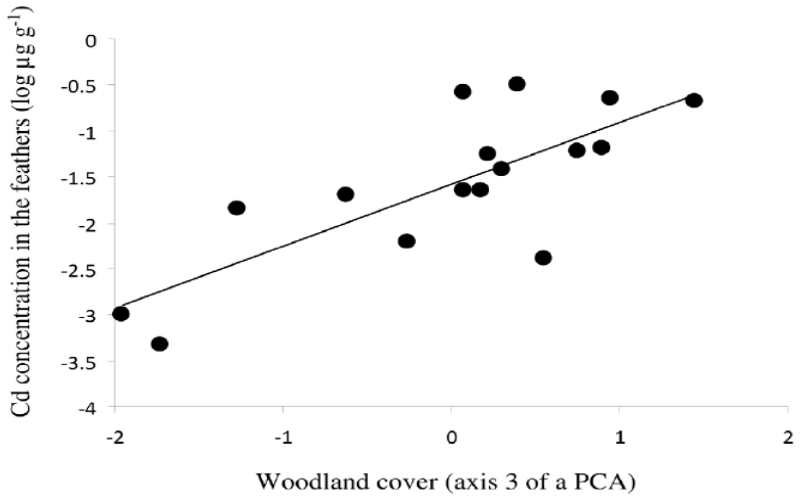
There is a complex relationship between *Plasmodium relictum*, Cd and Pb concentrations in feathers and the landscape in the house sparrow

(a)



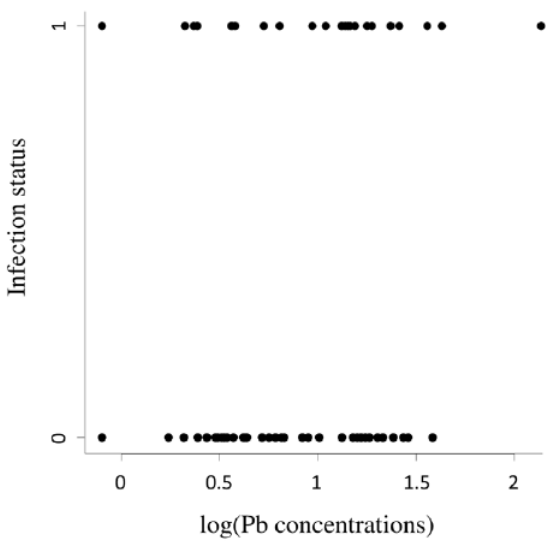
More urbanized Less urbanized

(b)

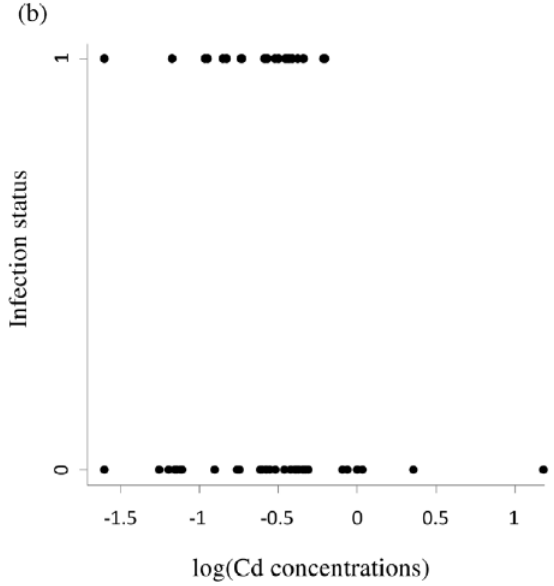


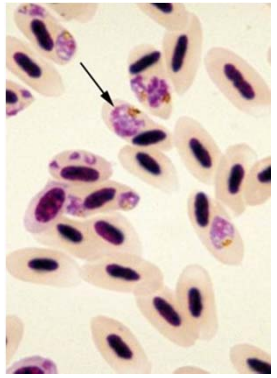
Less woodlands More woodlands

(a)



(b)





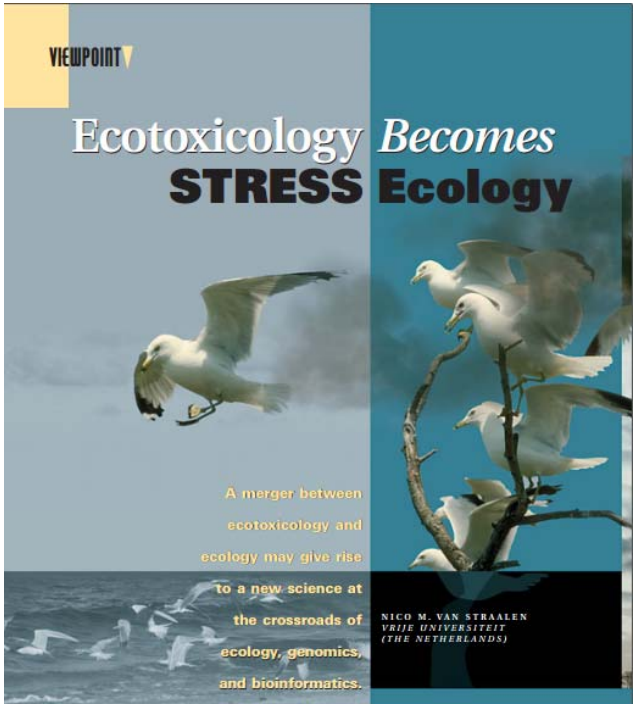
Bichet et al. 2013. *PLoS ONE*, 8(1): e53866.

Take-home messages and perspectives

- ✓ Ecotoxicology is moving to a more integrative systemic approach

- ✓ Rodents exhibit some (sub-)individual effects linked to their exposure to metals in Metaleurop Nord… but are pretty tolerant!

- ✓ Relationships between individual and population effects are unknown and remain a challenge in ecotoxicology



- ✓ There are (complex) relationships between metal concentrations and prevalence of some pathogens but underlying mechanisms and conservation consequences are unknown

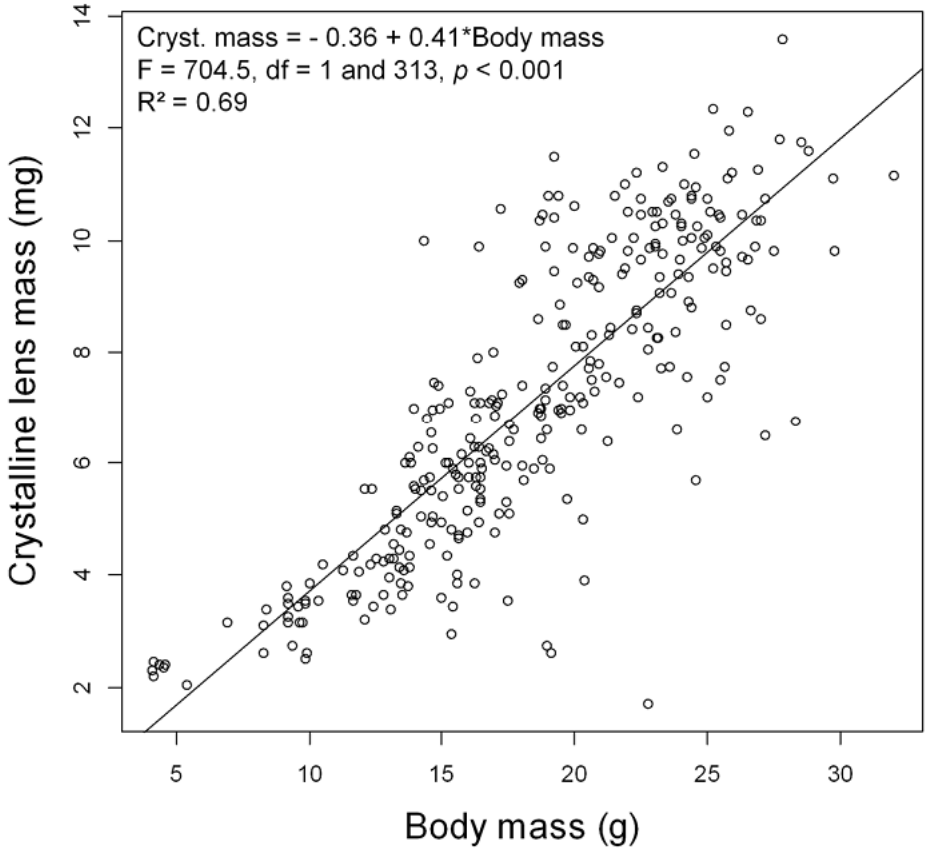


Figure III.S2. Relationship between crystalline lens mass (commonly used as an estimator of relative age) and the entire body mass (including digestive tracks and potential embryos) of wood mouse individuals (n = 315) from Metaleurop.

Supplementary material of Tête et al. 2014. *Ecotoxicology and Environmental Safety*, 108: 233-241.
http://dx.doi.org/10.1016/j.ecoenv.2014.07.010