Developing a General Understanding of the Decomposition Process: Results of a Network Experiment

Mark E. Harmon

Richardson Chair and Professor

Department of Forest Science

Oregon State University

Thanks to!

- **Becky Fasth, Jay Sexton, and many, many others throughout the LTER network for their help in installing and maintaining the experiments**
- **The NCEAS Decomposition Working Group**
- **NSF-LTER, LTRB, Ecosystems, NCEAS for funding**

Decomposition is an important process to understand

- **Controls accumulation of organic matter**
- **Carbon dynamics of ecosystems**
  - **Present and future**
- **Nutrient release for plants**
- **Decomposed material influences soil properties**
- **Ecosystem indicator of pollution**

Compared to production we know little about decomposition

- **Relatively few studies on decomposition**
- **Few global views of process-studies generally local**
- **Few global models of process**
- **Few databases to drive global calculations**
- **Uncertainty about long-term dynamics**

LIDET: Long-term Intersite Decomposition Experiment Team

To what degree does climate versus substrate quality control:

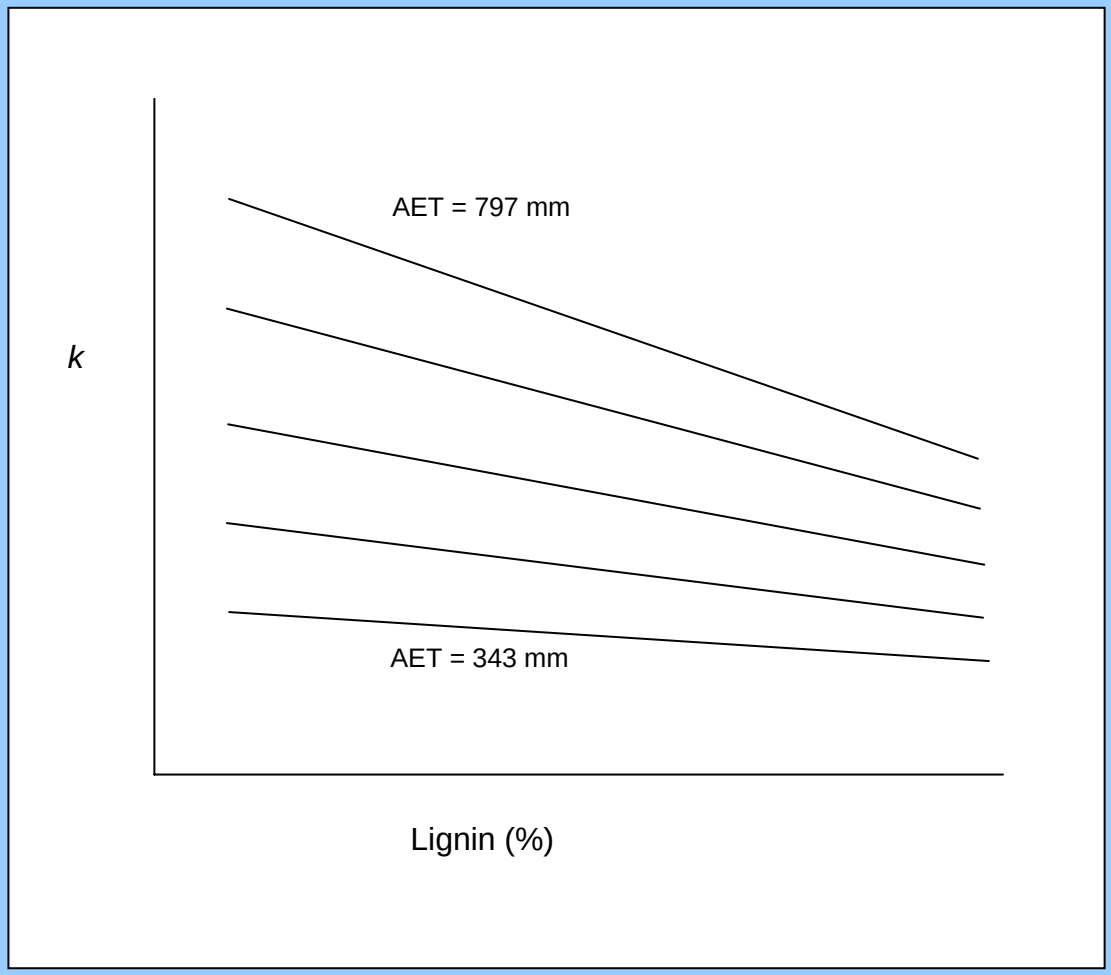
The rate of decomposition?

Hypothesis: they interact

The formation of stable organic material?

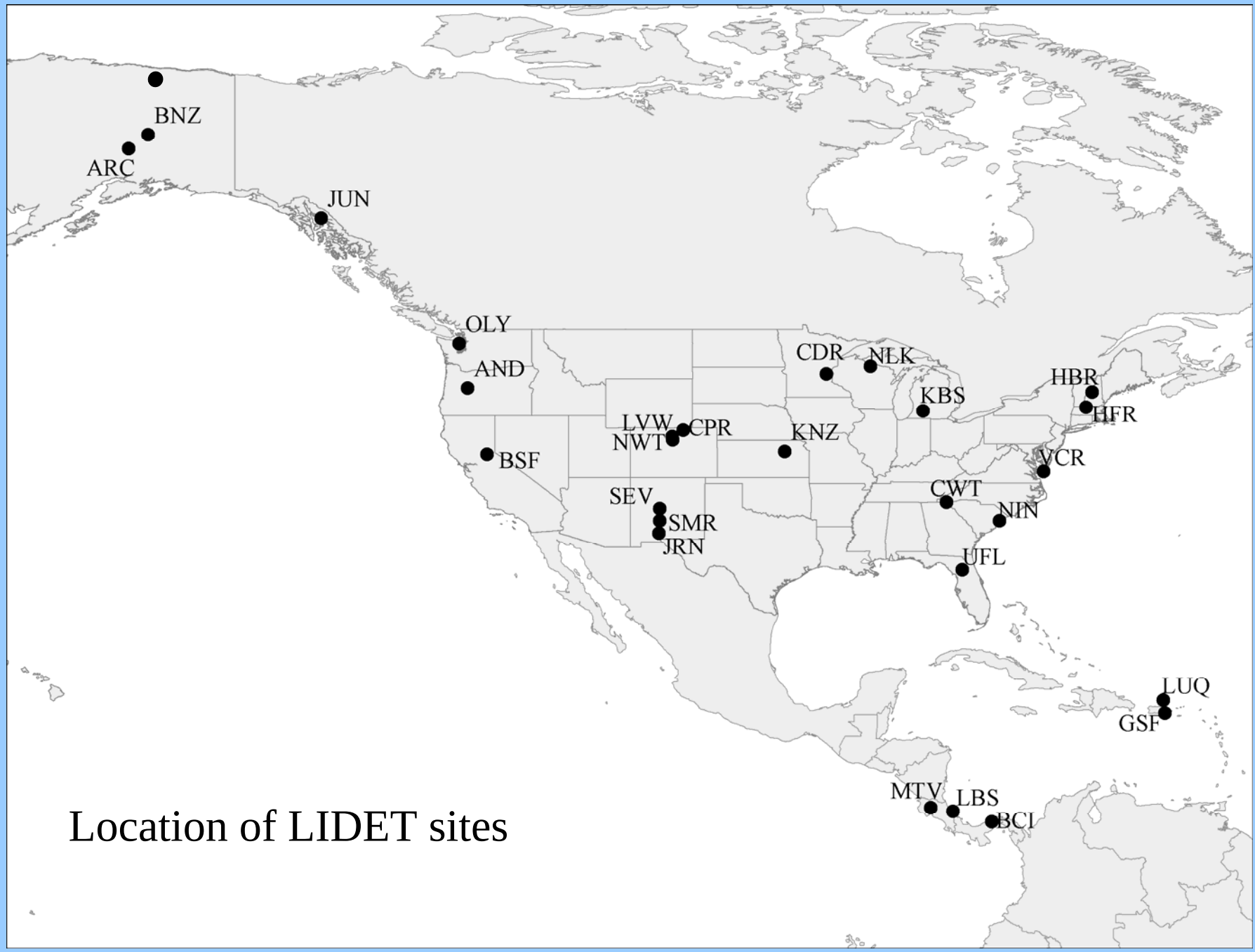
Hypothesis: no effect of either, a constant 15%

Climate-Substrate Quality Interaction-Meentemeyer (1978)



Background

- **1988 Wood's Hole workshop at Marine Biological Laboratory**
  - **LIDET; DIRT experiments designed**
- **1989 Litter collected, bags filled**
- **1990-91 Litter placed in field**
- **2002 field work completed**
- **2003-2006 NCEAS working group**

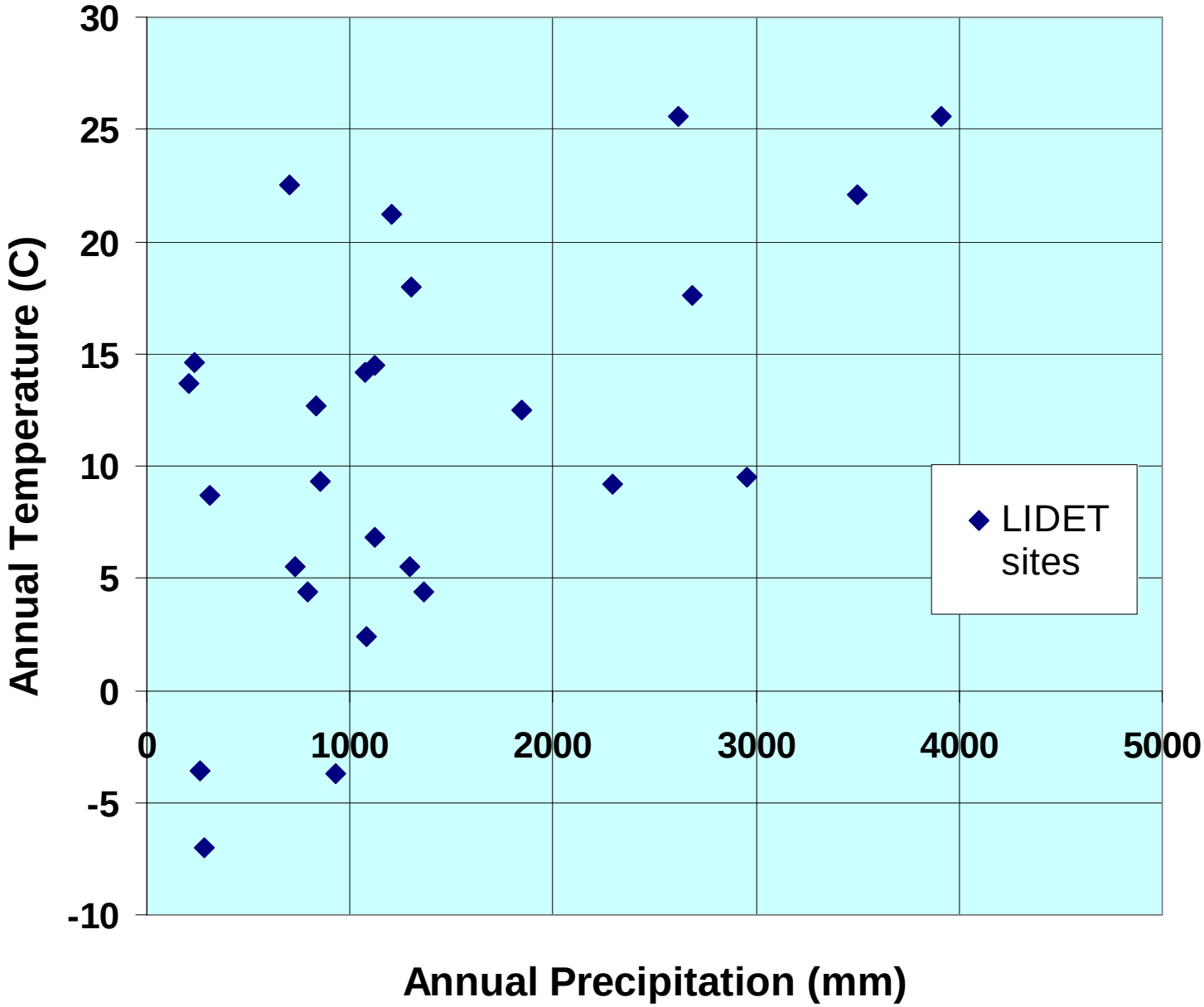


Location of LIDET sites

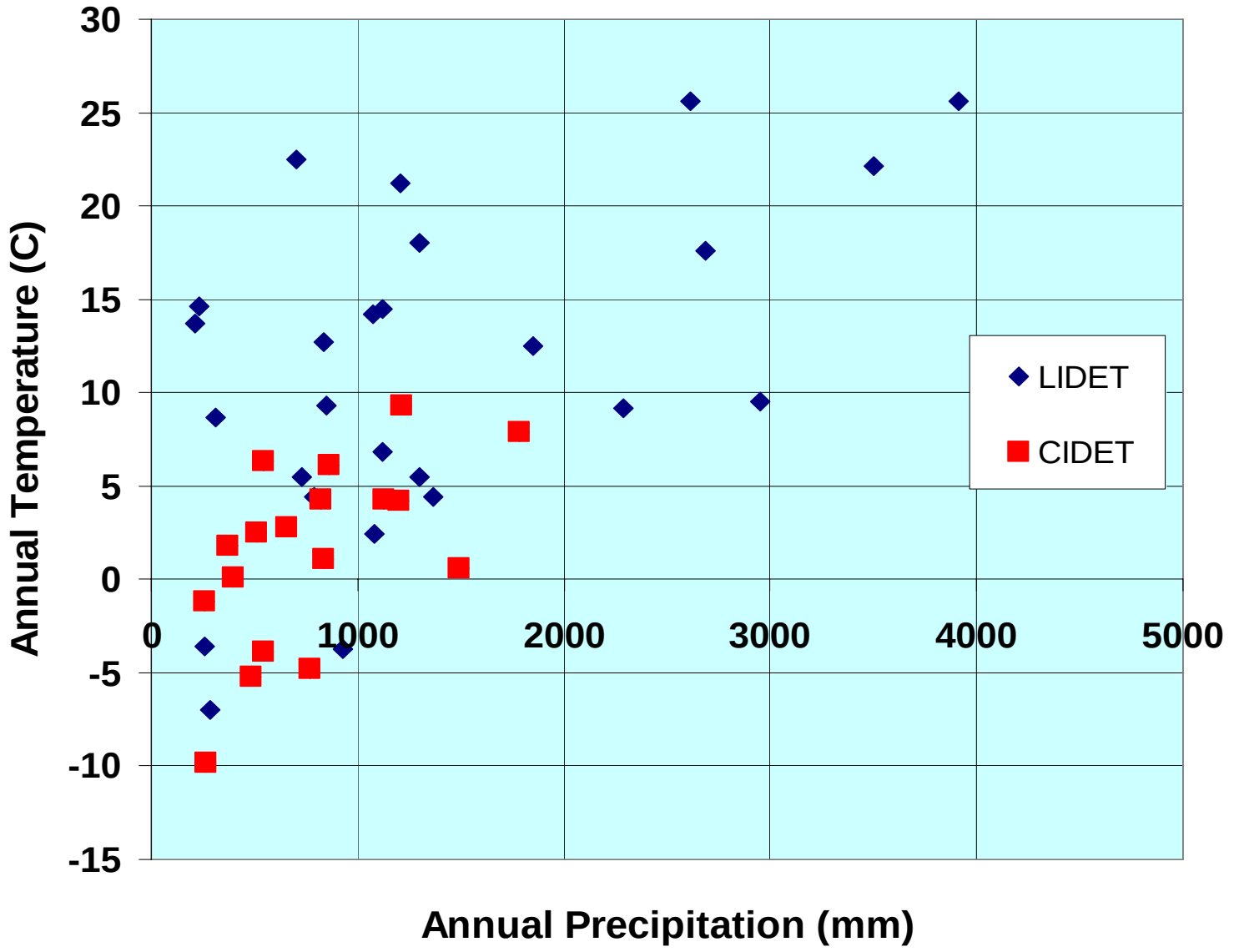
Existing North American Networks

- **LIDET: Long-term Intersite Decomposition Experiment Team**
- **CIDET: Canadian Intersite Decomposition Experiment**

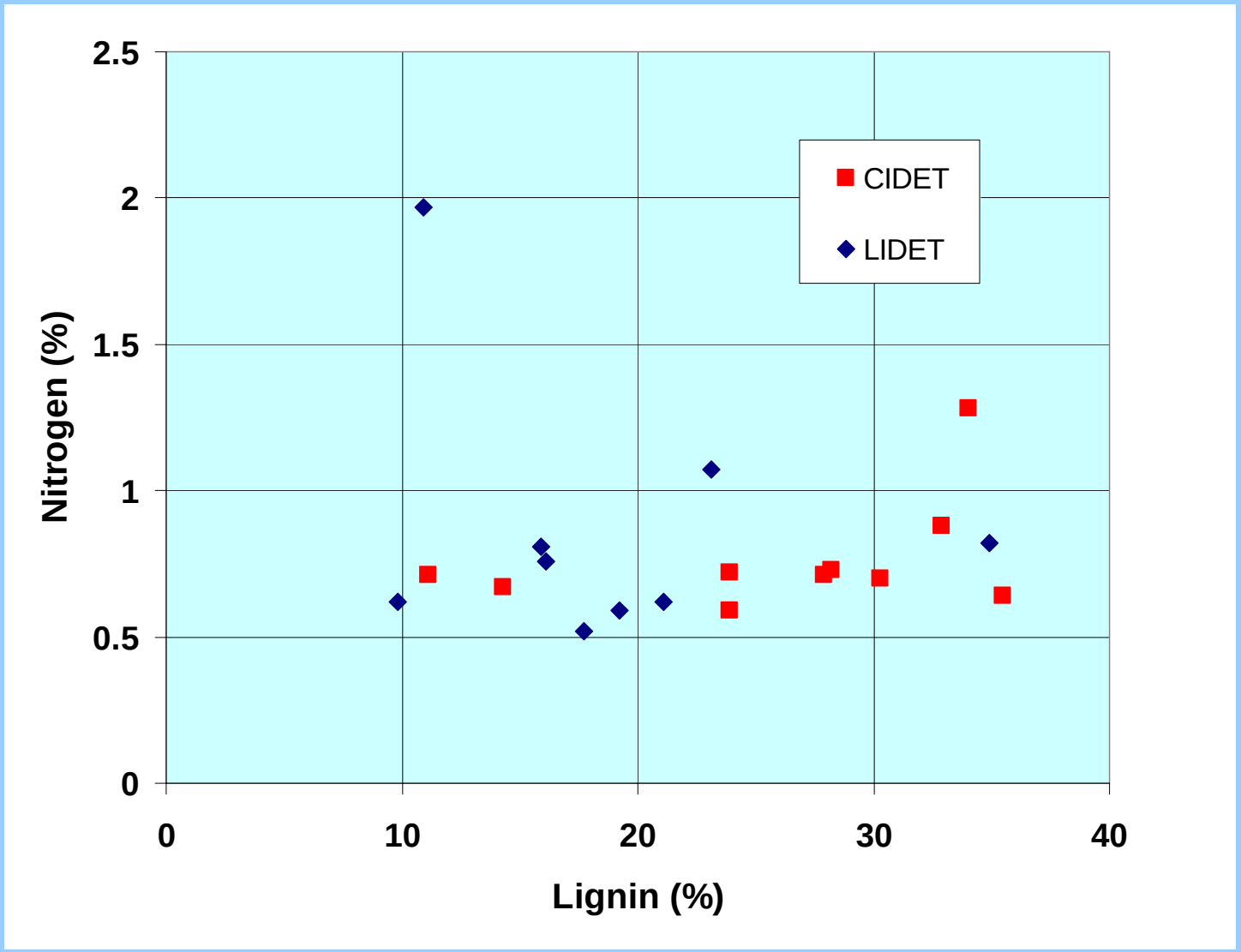
Climatic Fields-LIDET



Climatic Fields-LIDET & CIDET



Substrate Quality: Lignin v. Nitrogen



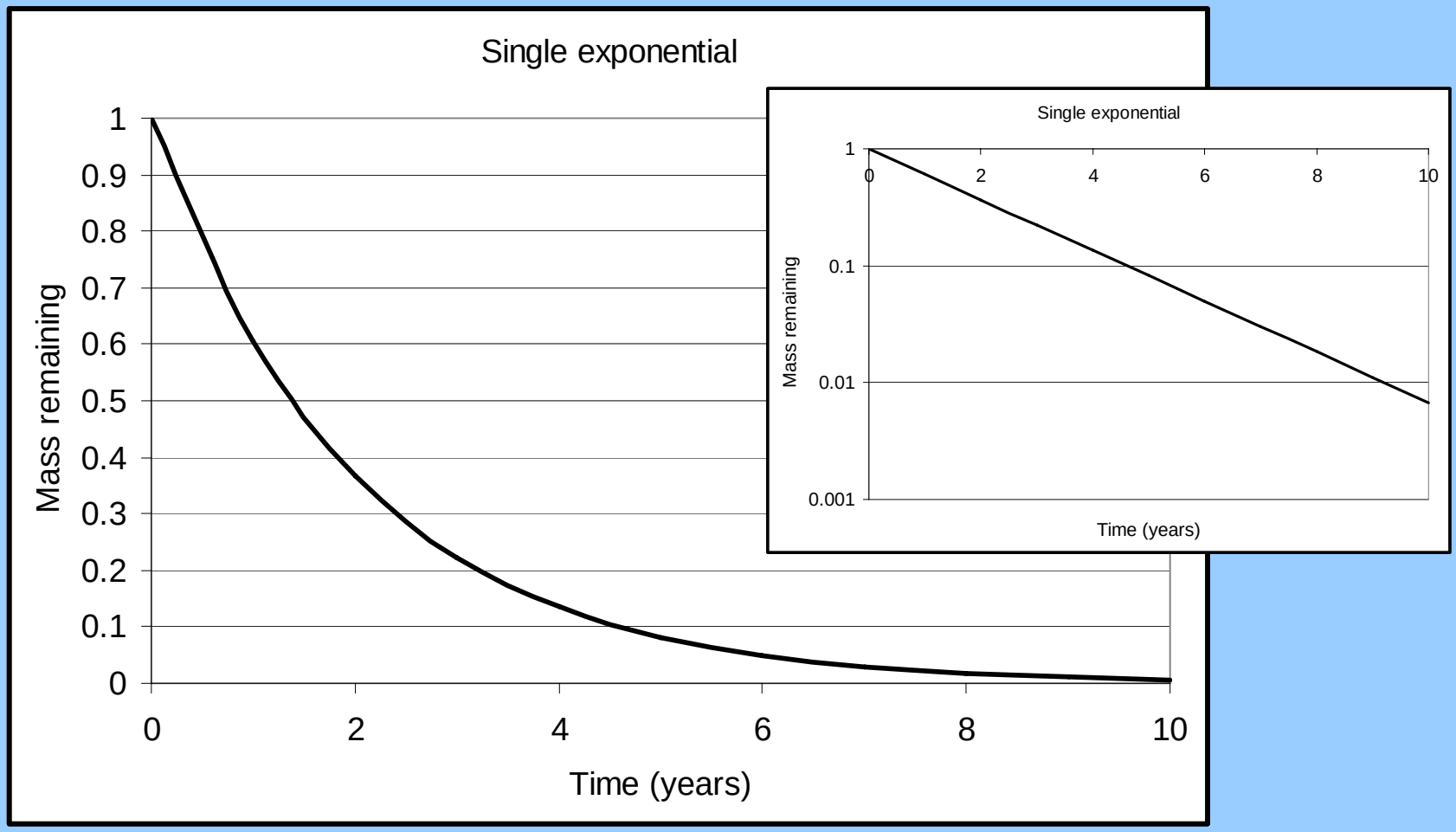
Steps Involved

- **Collection of litter as selected sites**
- **Preparation of litterbags; data set built**
- **Sent to 28 sites**
- **Site periodically send data and litter back**
- **Initial Quality control checks, data entry, preliminary analysis**
- **Lab analysis**

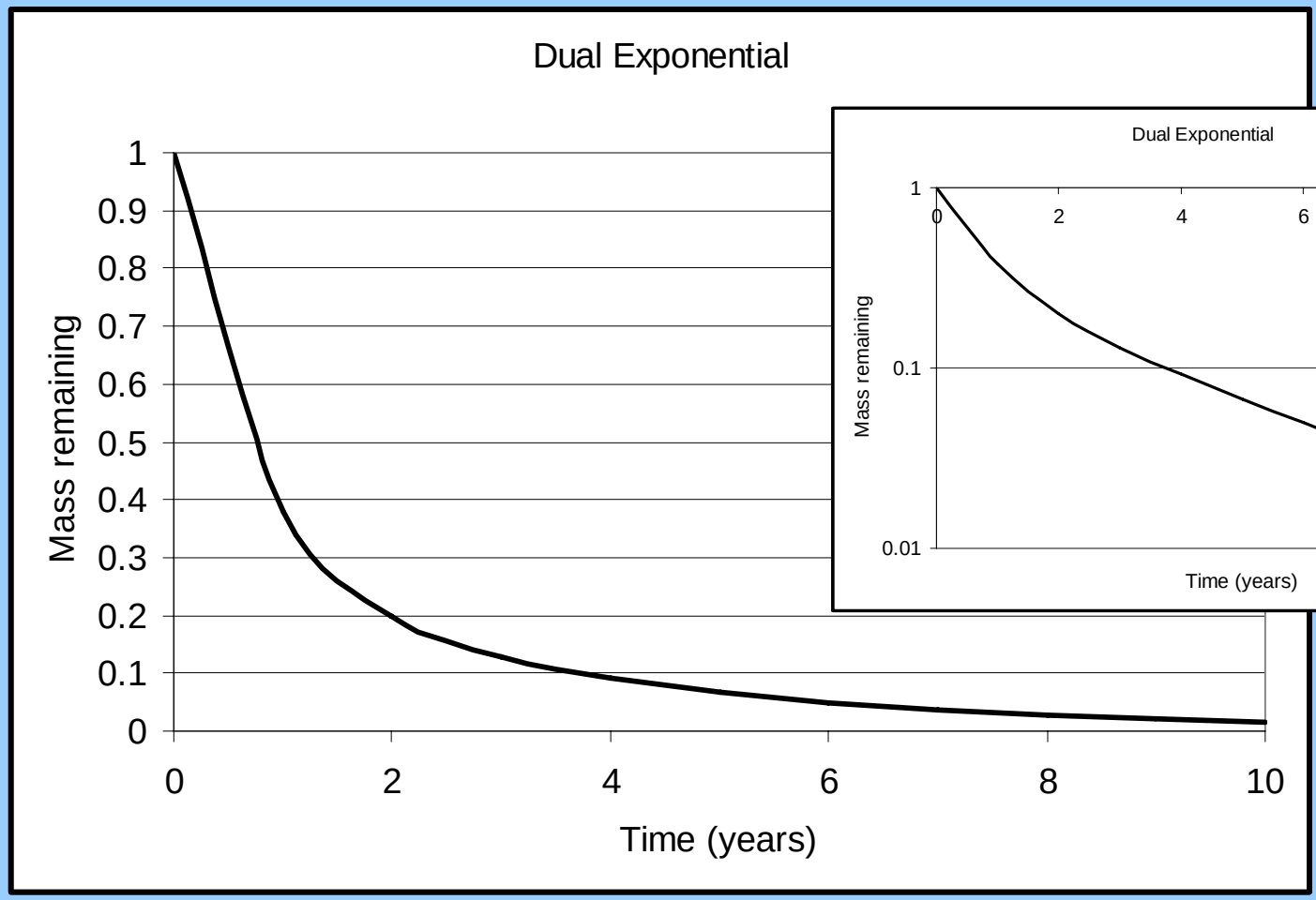
Litter bags
20X20 cm
On surface

Root bags
20X20 cm
Buried ~10 cm

Models Examined
Mt=M0 exp[-kt]

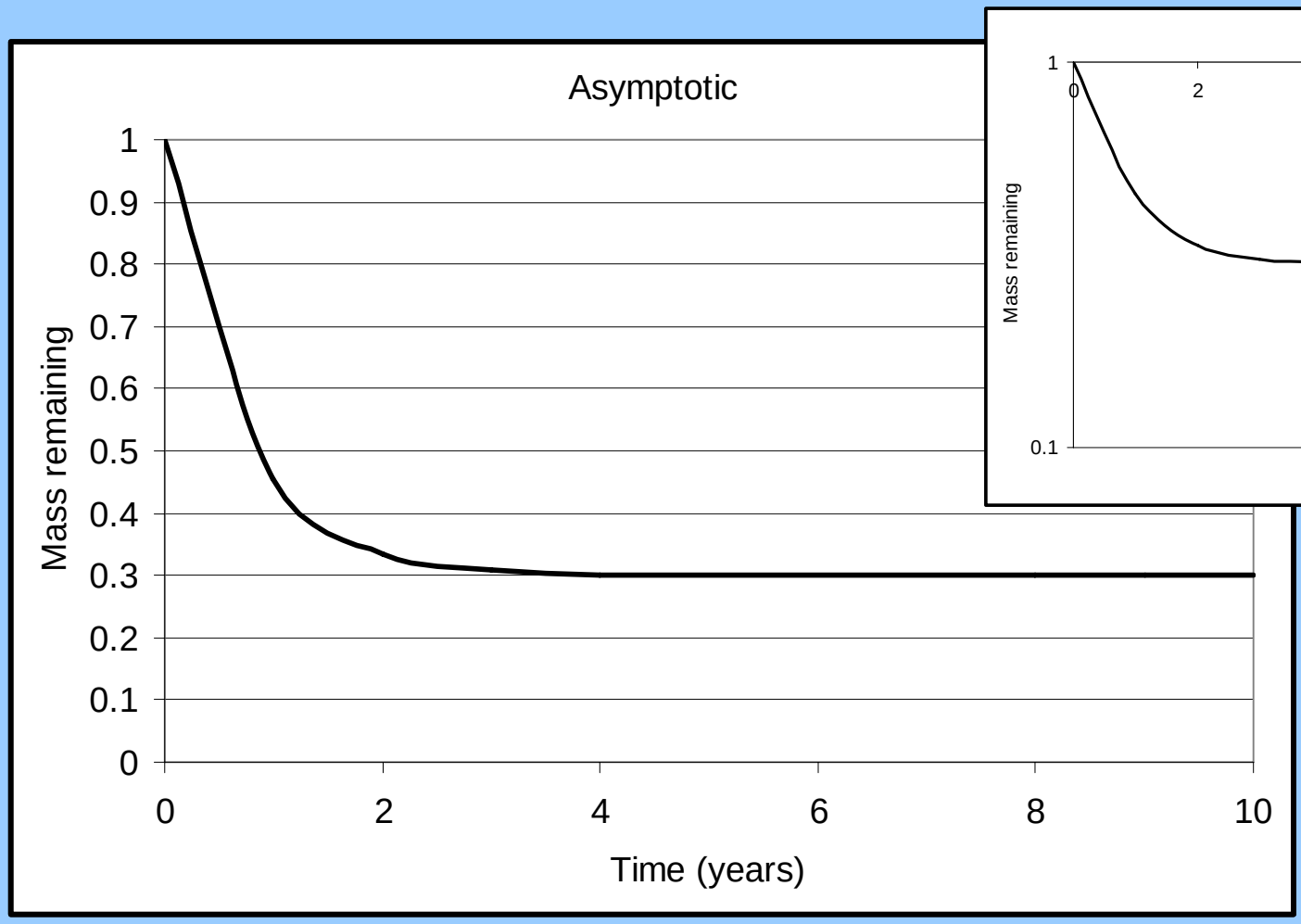


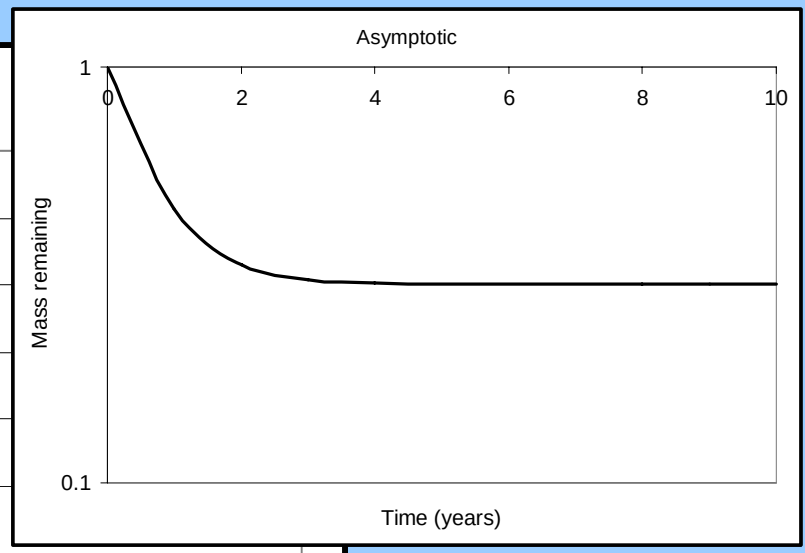
Models Examined
Mt=Mf0 exp[-kft]+Ms0 exp[-kst]

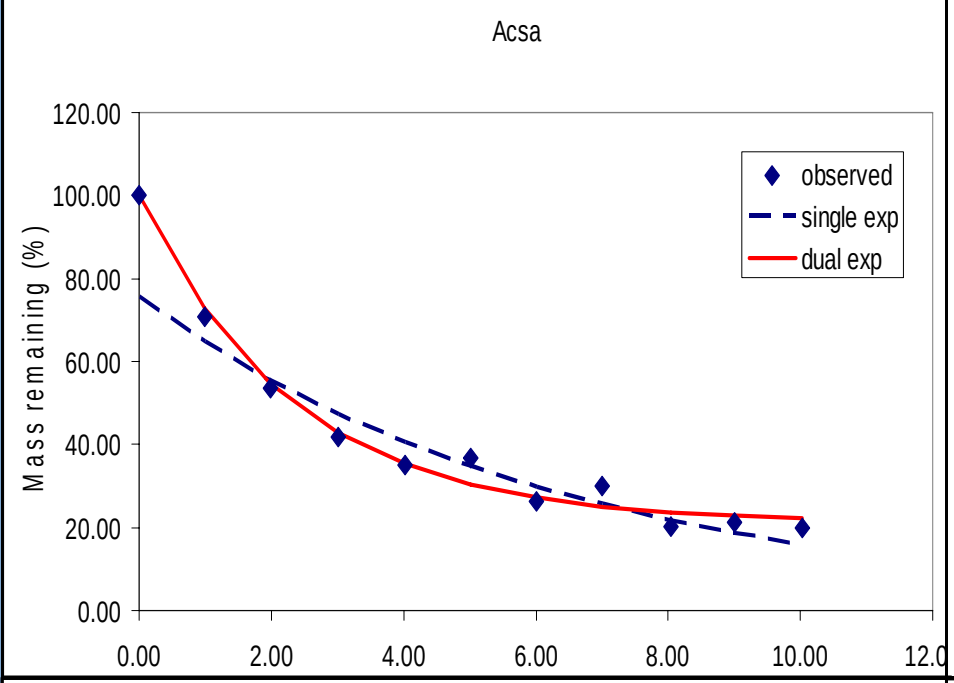


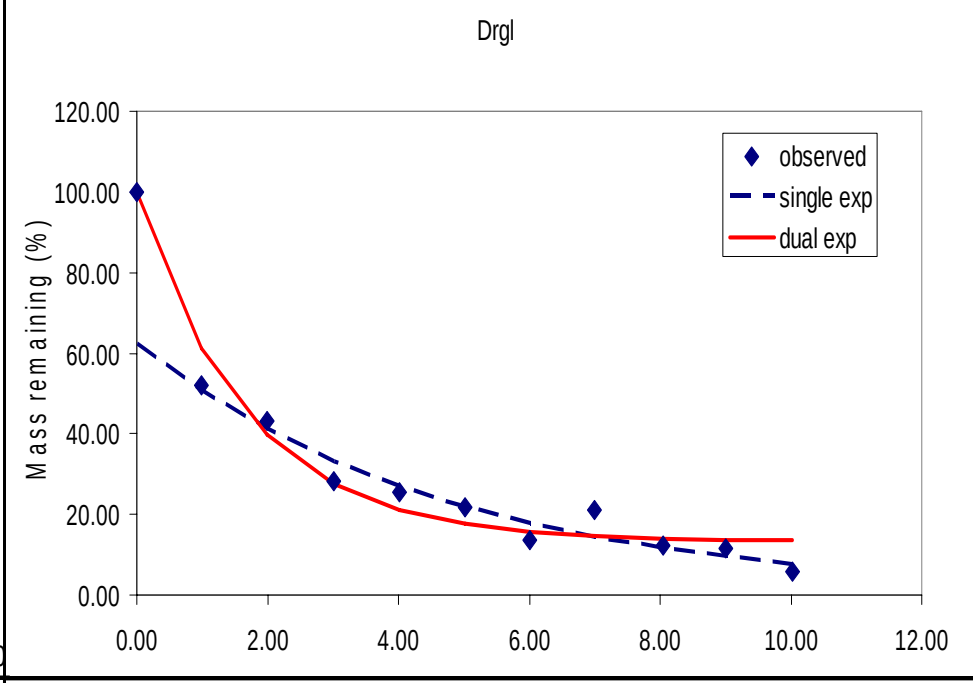
Models Examined

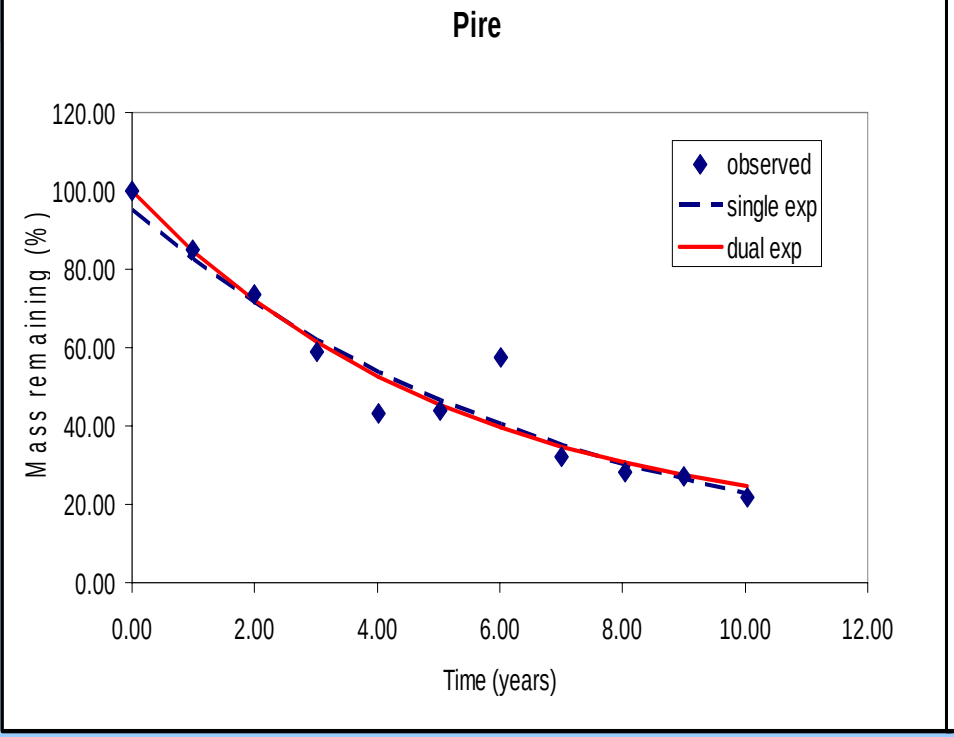
$$Mt = Mf0 \exp[-kft] + M_{stable}$$

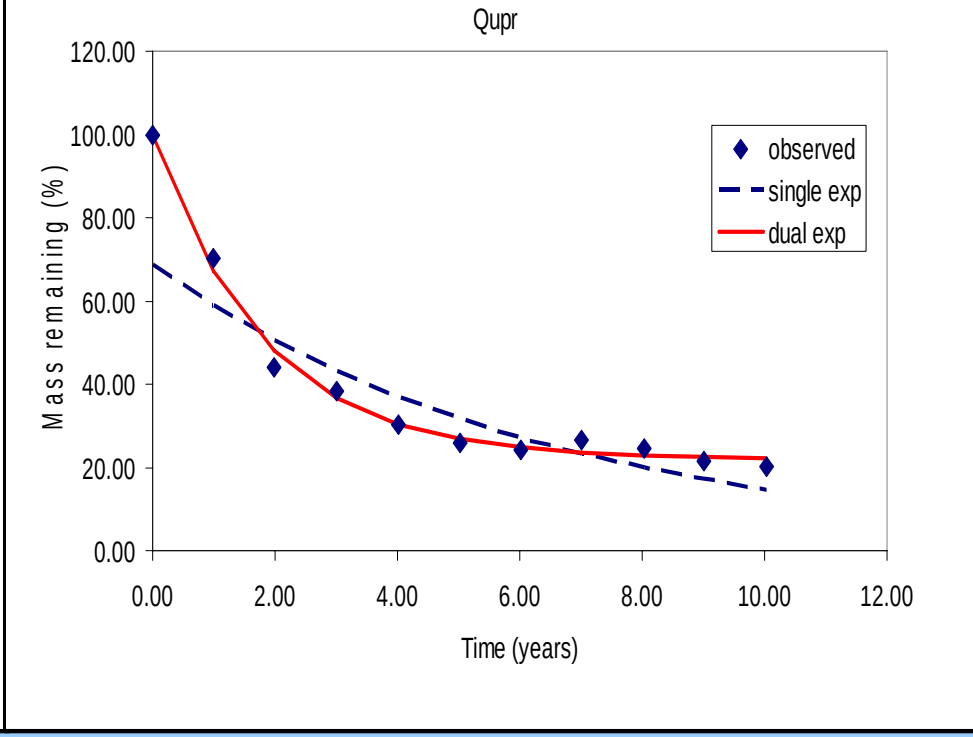


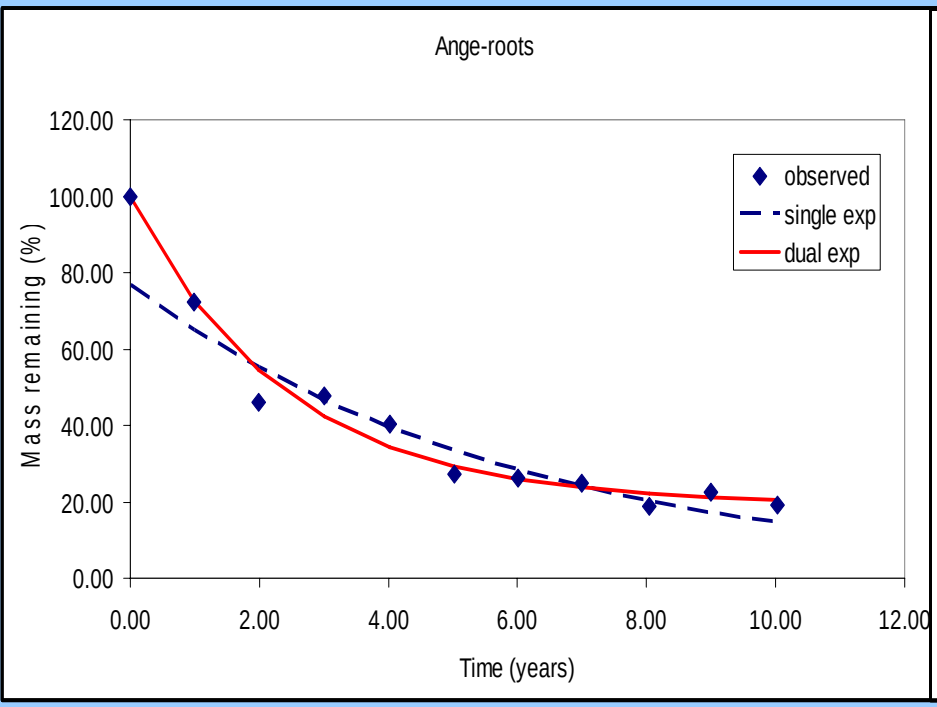


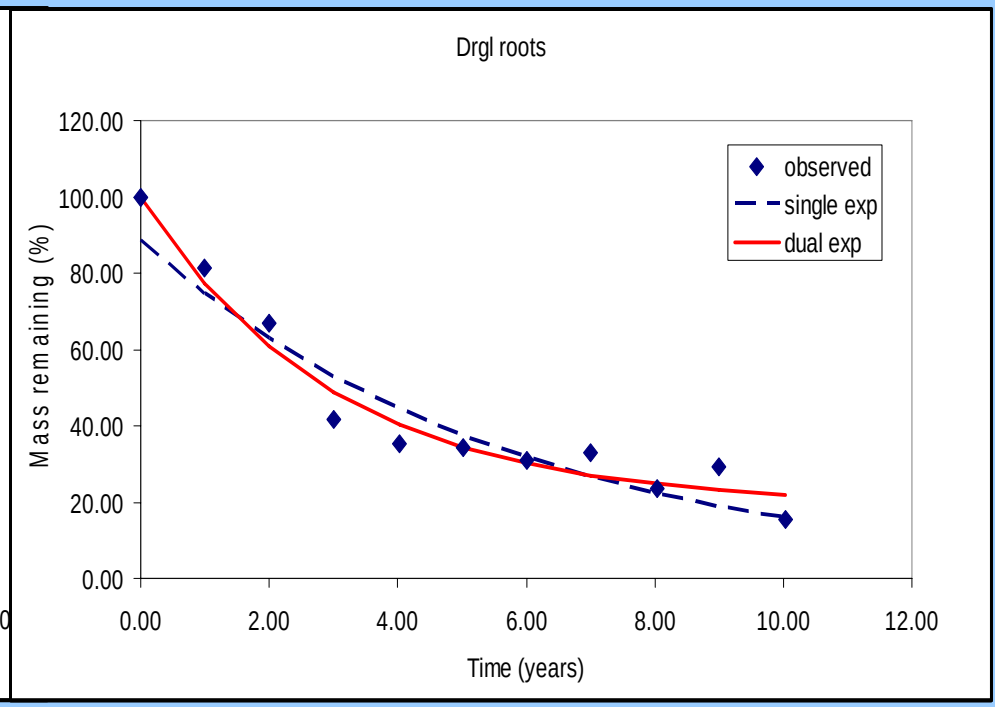

Acsa
Mass remaining (%)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.0
observed
single exp
dual exp

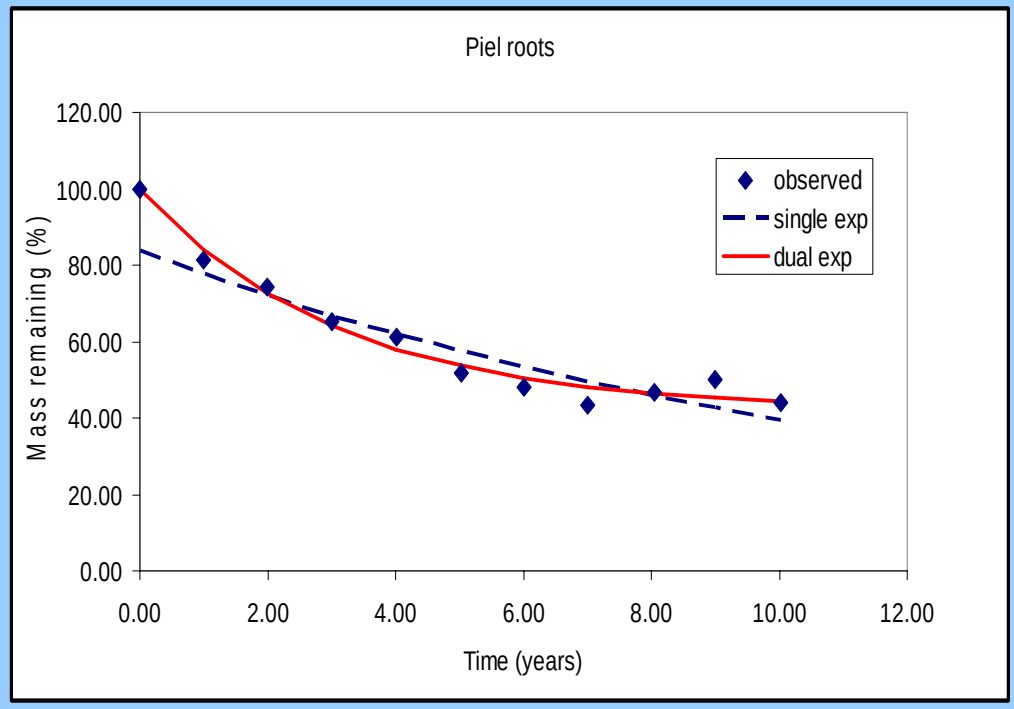

Drgl
Mass remaining (%)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
observed
single exp
dual exp


Pire
Mass remaining (%)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Time (years)
observed
single exp
dual exp

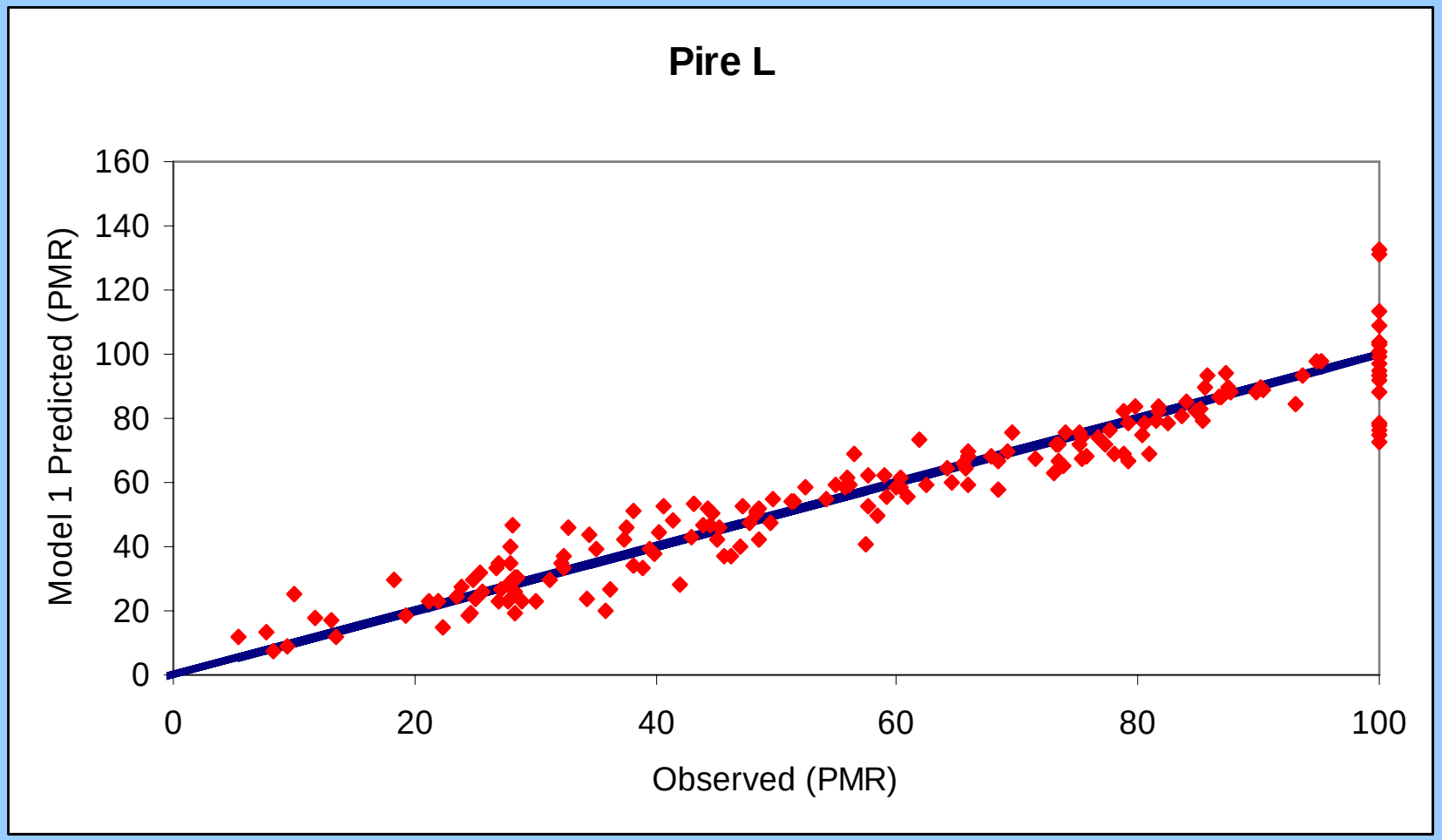

Qupr
Mass remaining (%)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Time (years)
observed
single exp
dual exp


Ange-roots
Mass remaining (%)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Time (years)
observed
single exp
dual exp

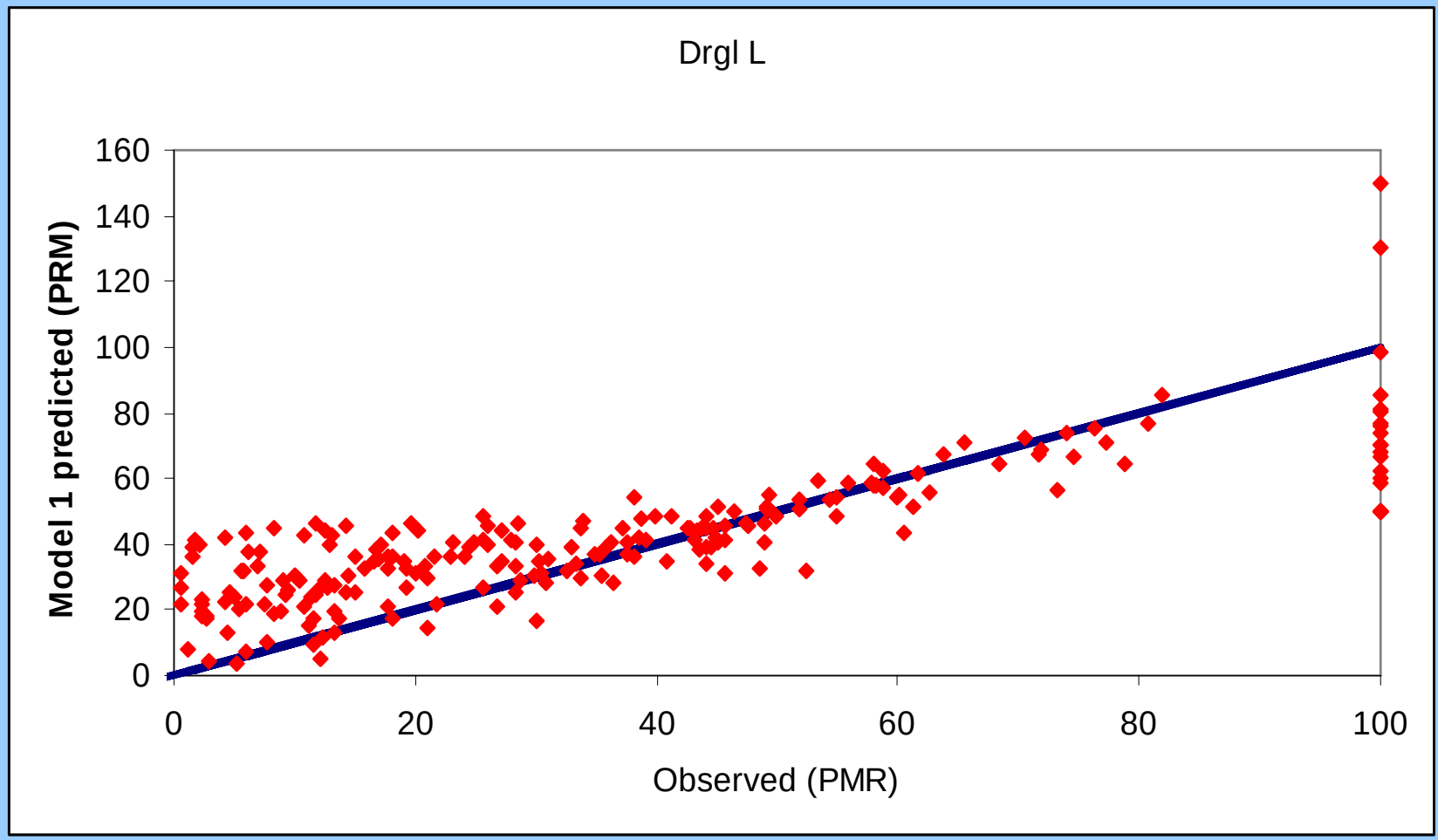

Drgl roots
Mass remaining (%)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Time (years)
observed
single exp
dual exp


Piel roots
Mass remaining (%)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Time (years)
observed
single exp
dual exp

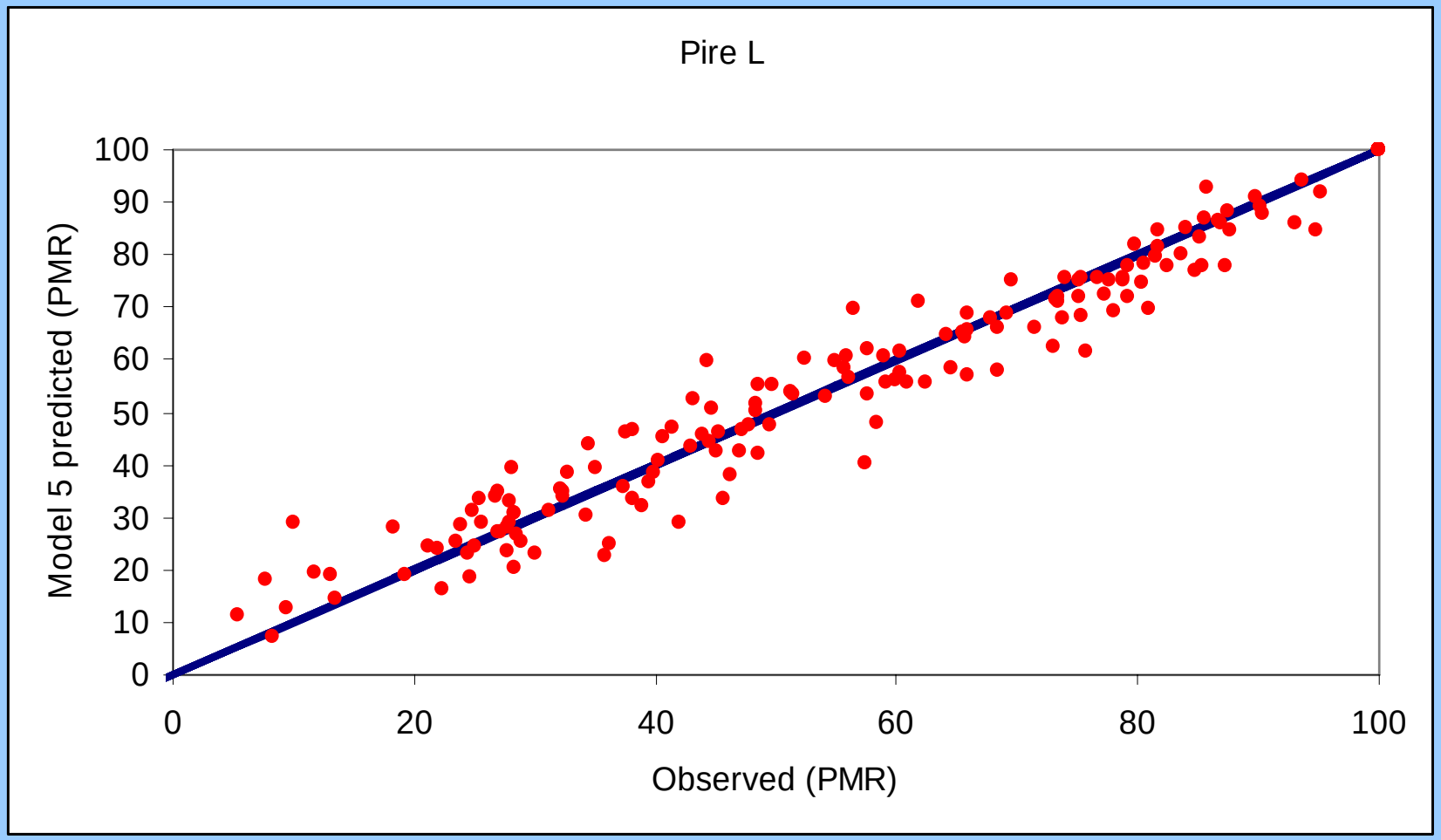
Single exponential-Pine leaves



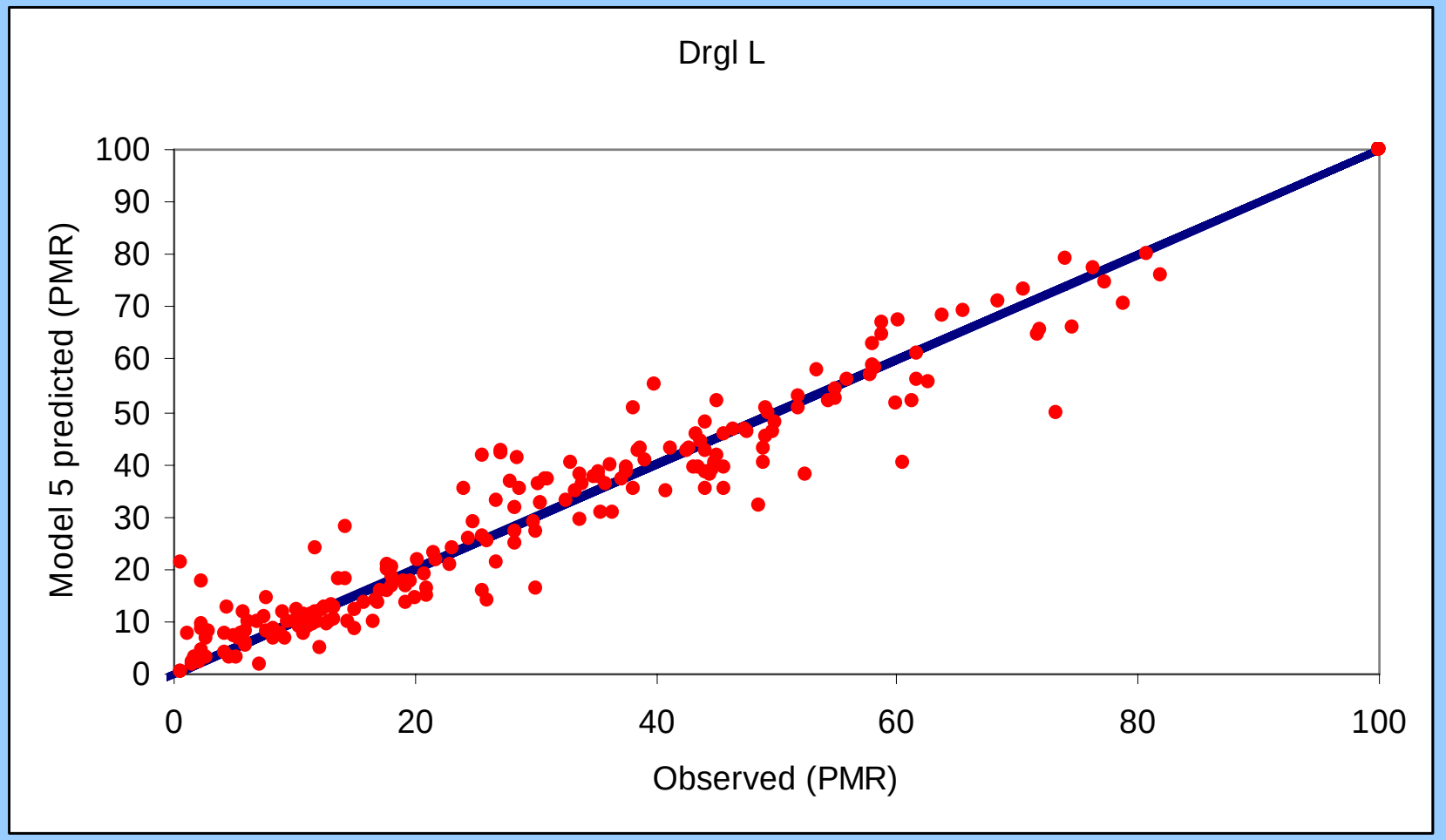
Single exponential-Drypetes leaves



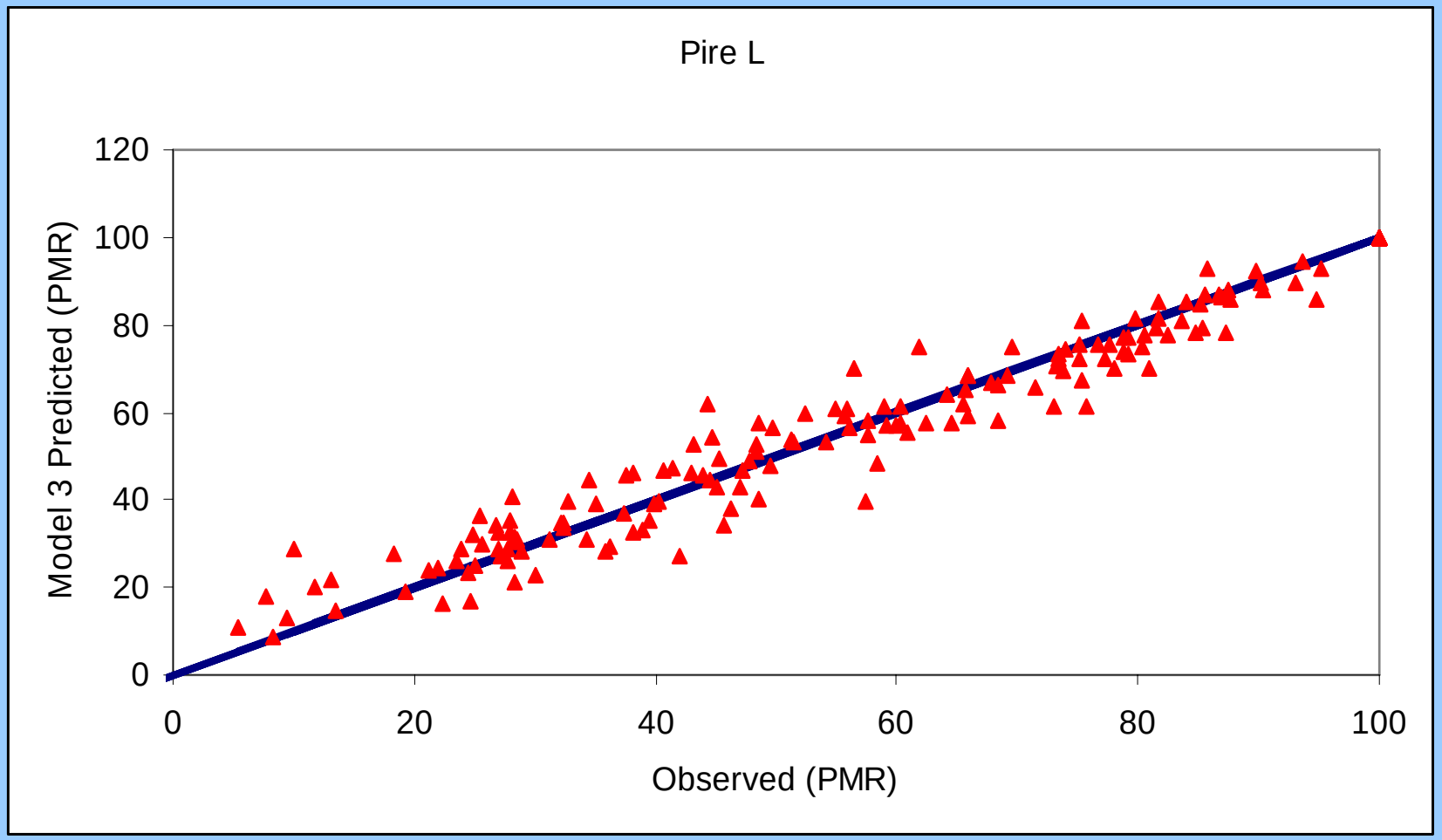
Double exponential-pine leaves



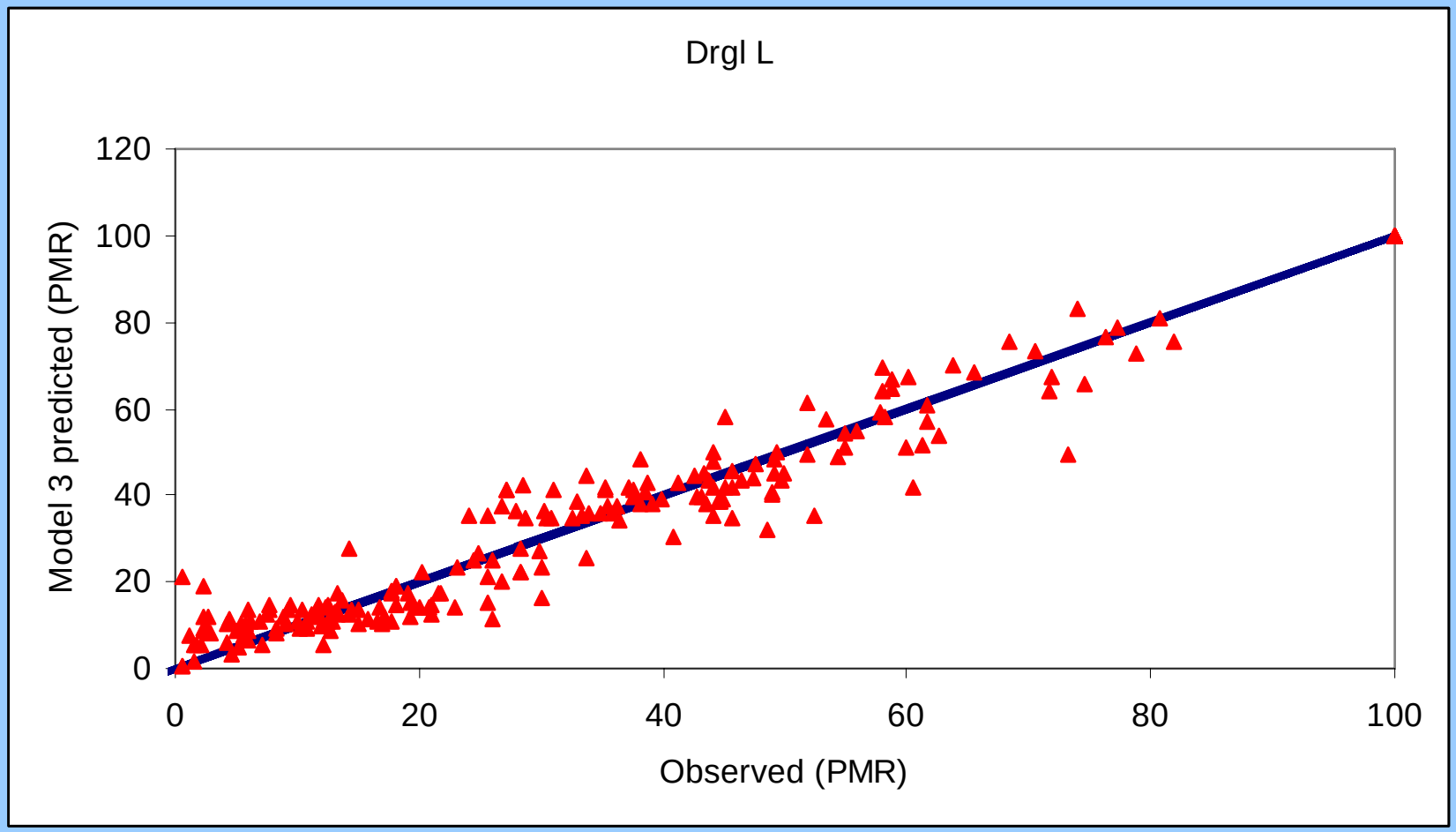
Double exponential-Drypetes leaves



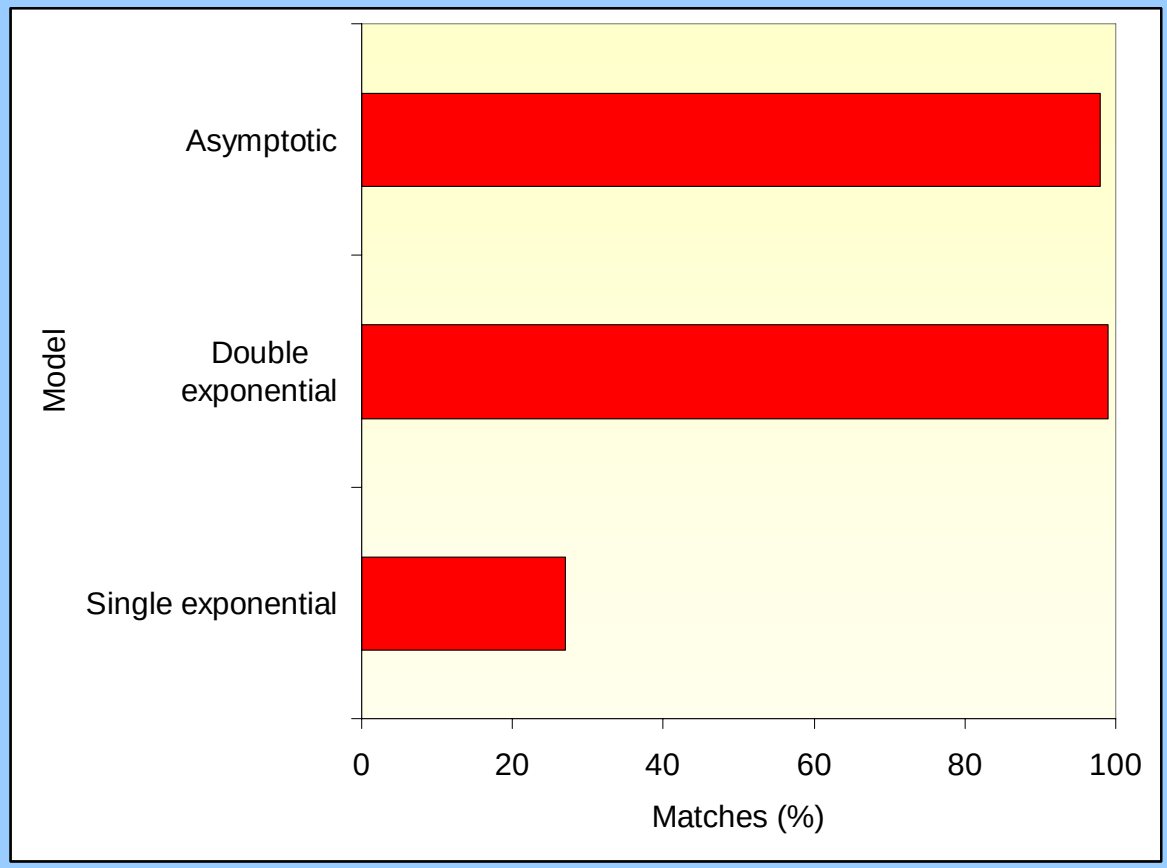
Asymptotic-pine leaves



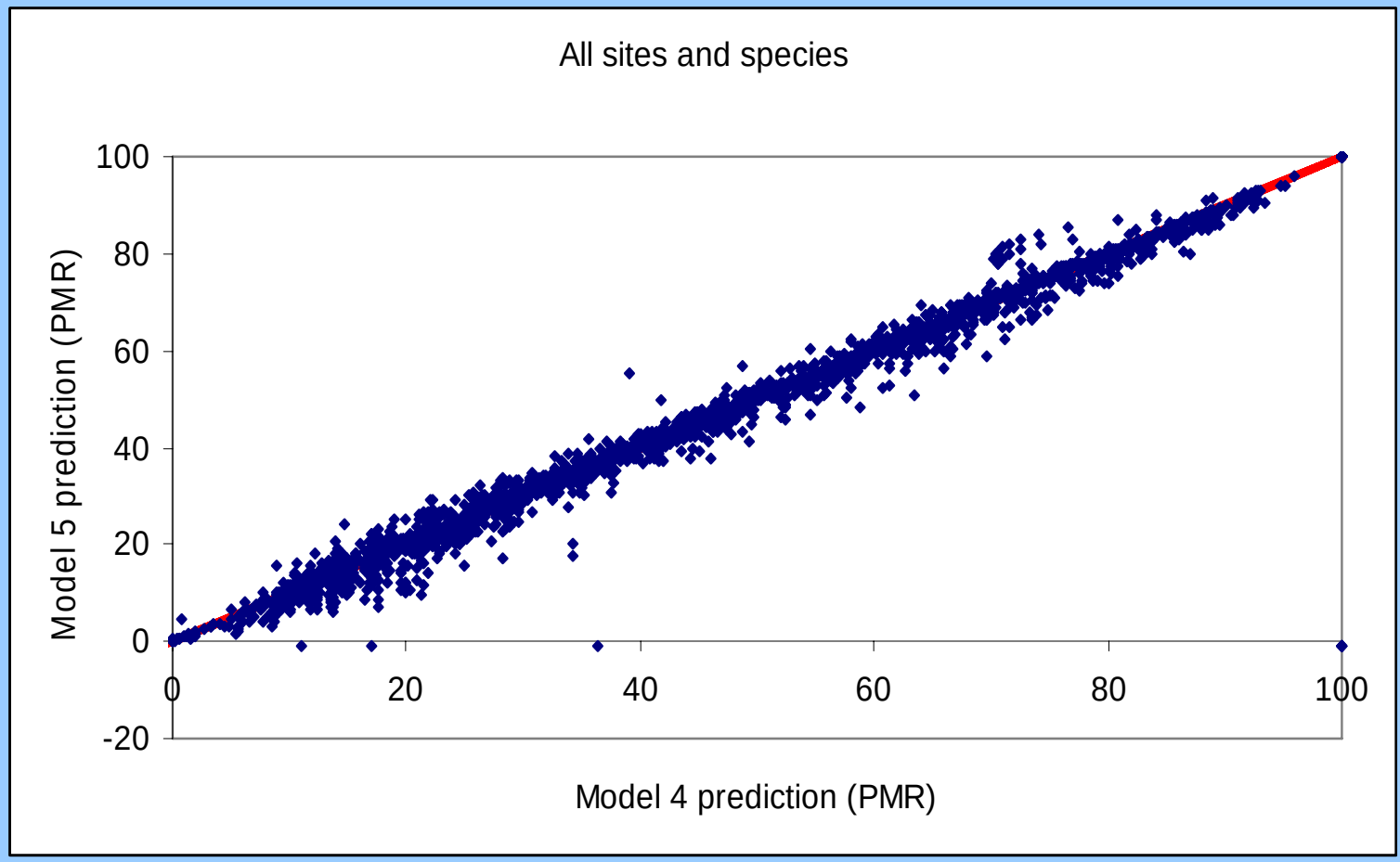
Asymptotic-Drypetes leaves



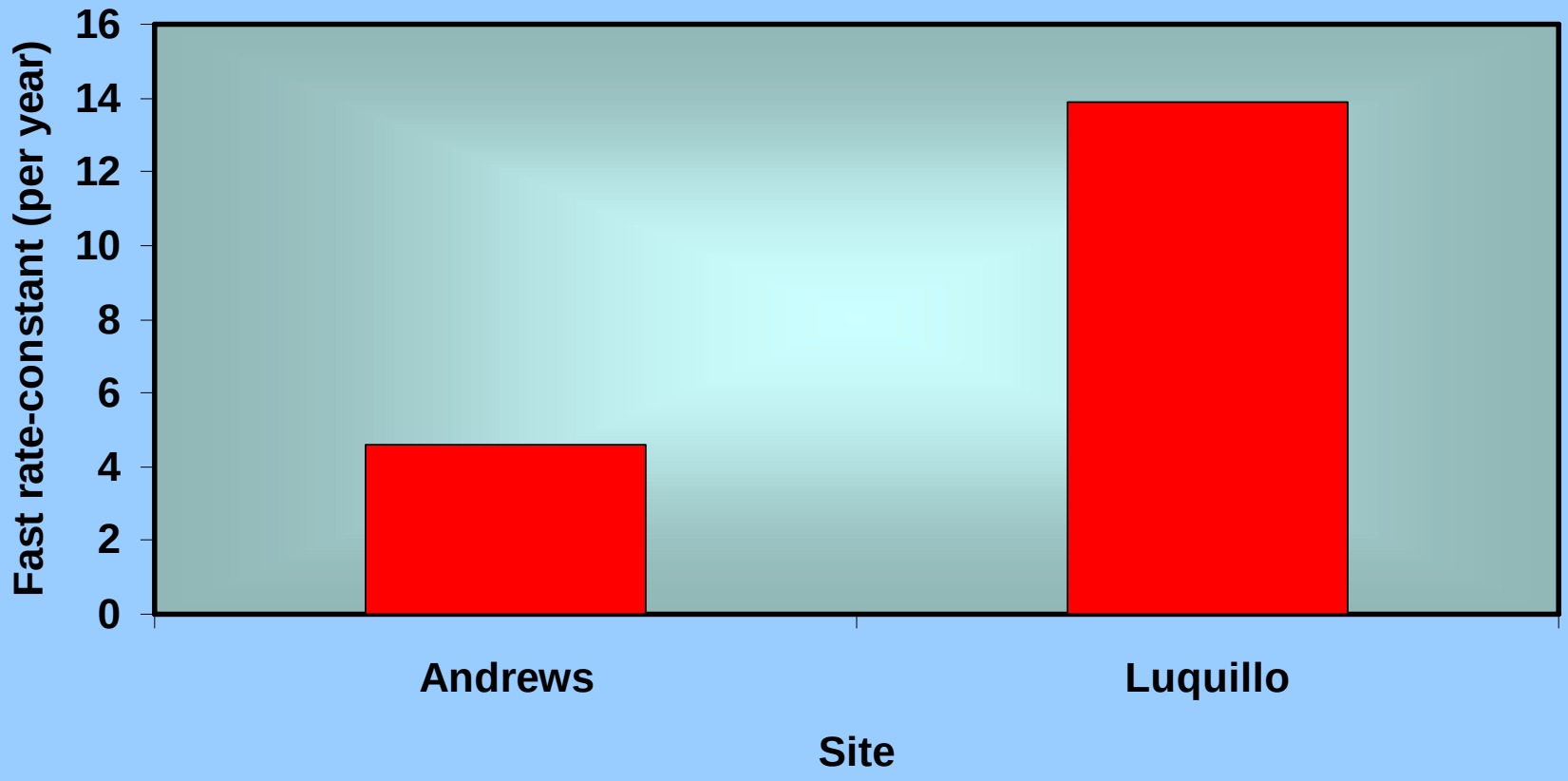
Which model is best?

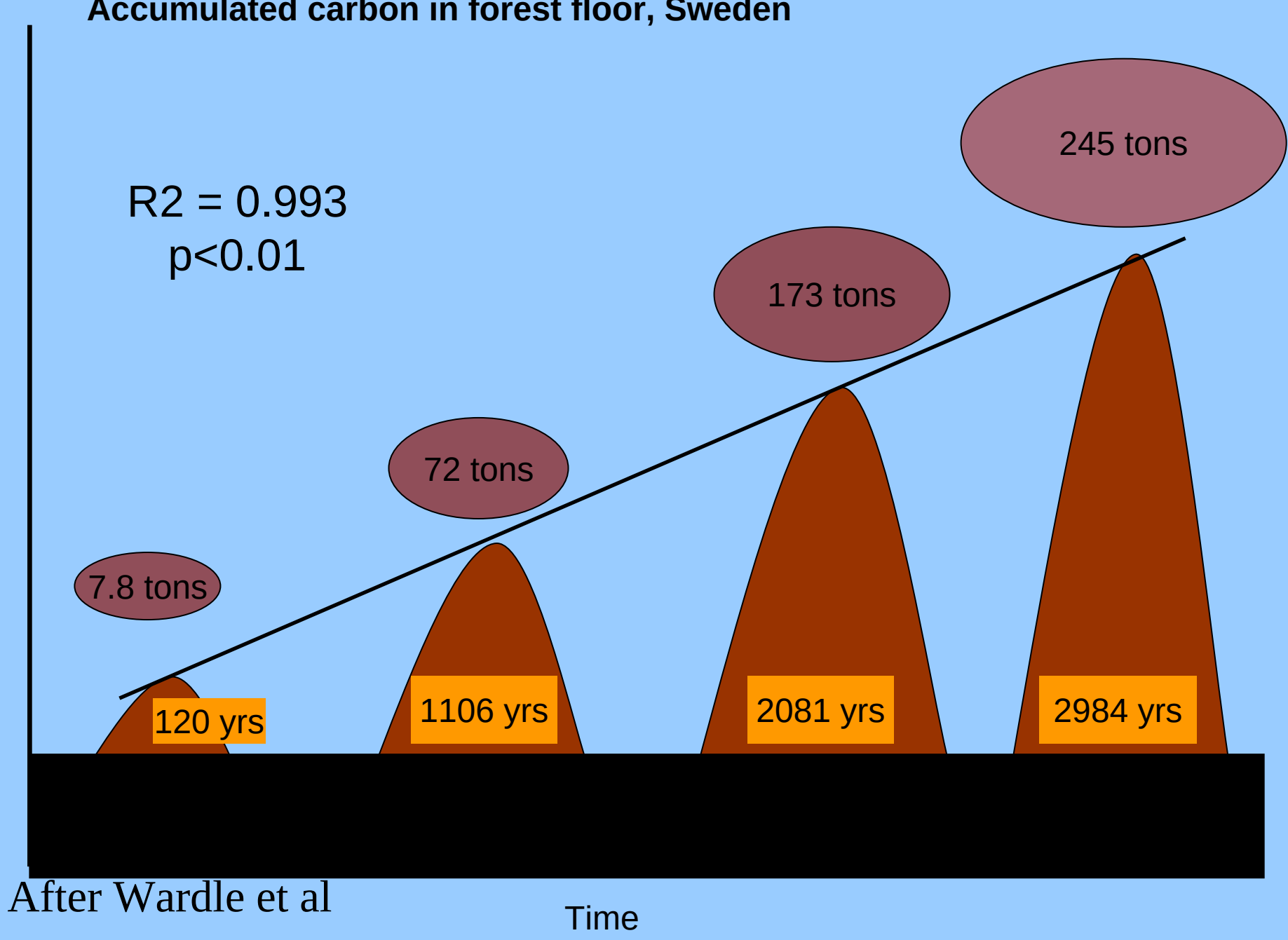


Dual Exponential v Asymptotic

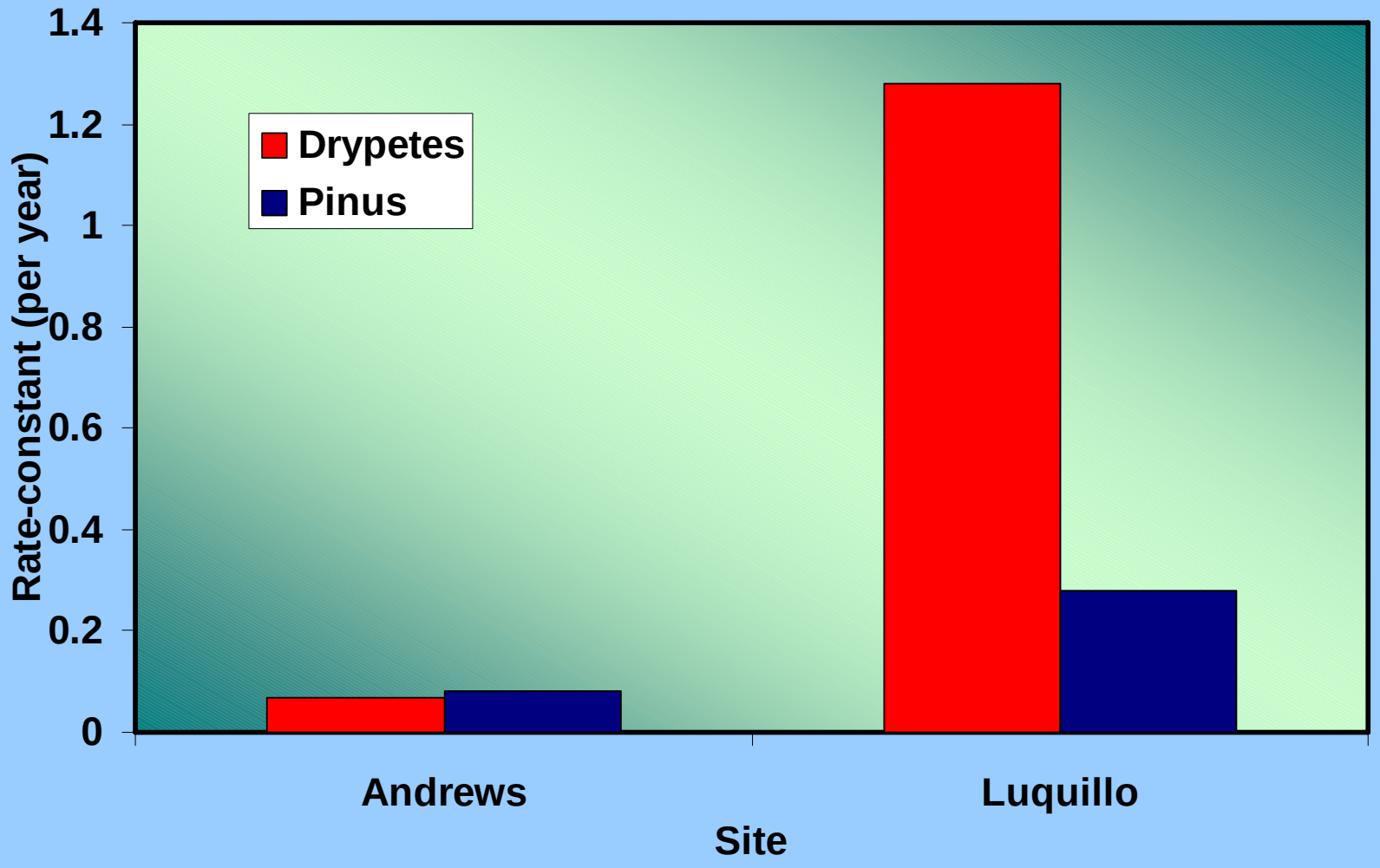


Decomposition Rate-constants of Fast Phase

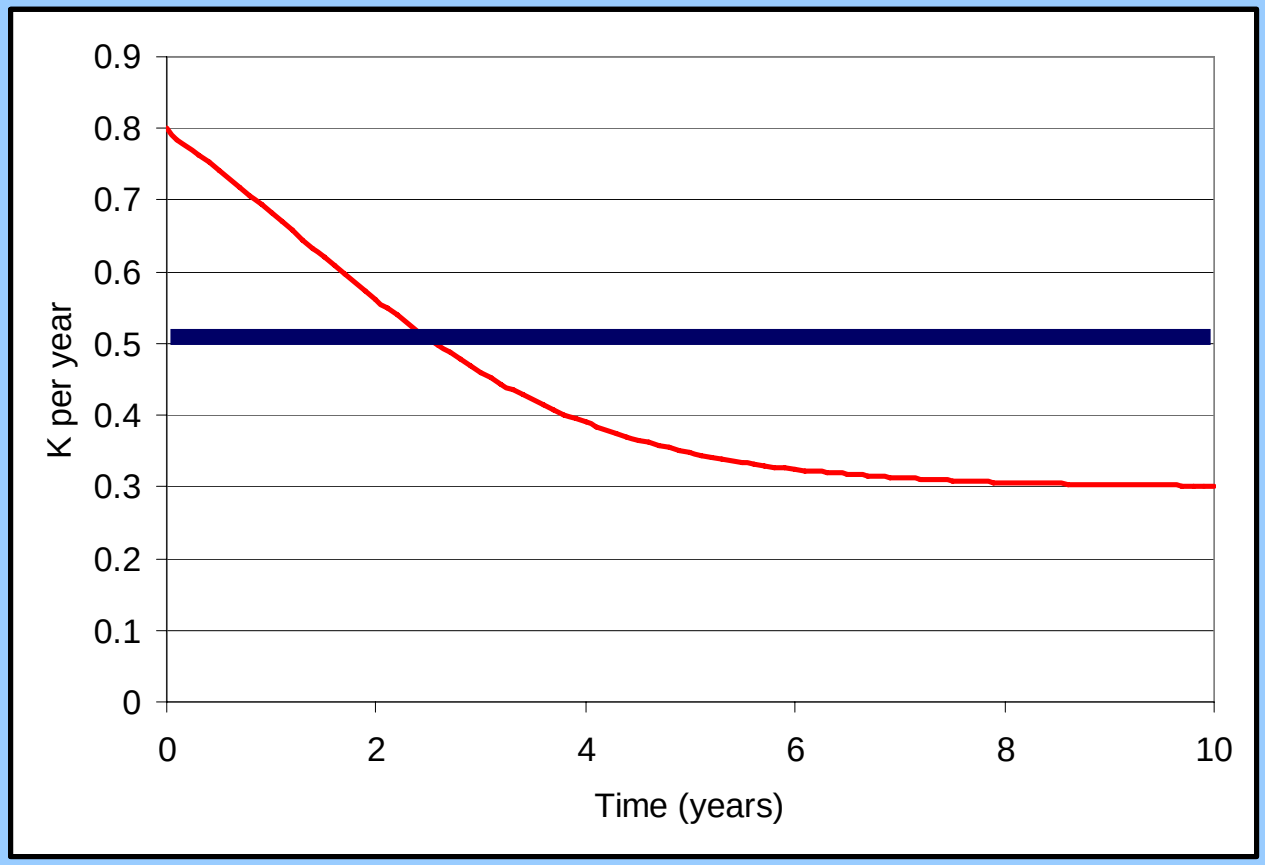



Accumulated carbon in forest floor, Sweden
R2 = 0.993
p<0.01
245 tons
173 tons
72 tons
7.8 tons
120 yrs
1106 yrs
2081 yrs
2984 yrs
After Wardle et al
Time

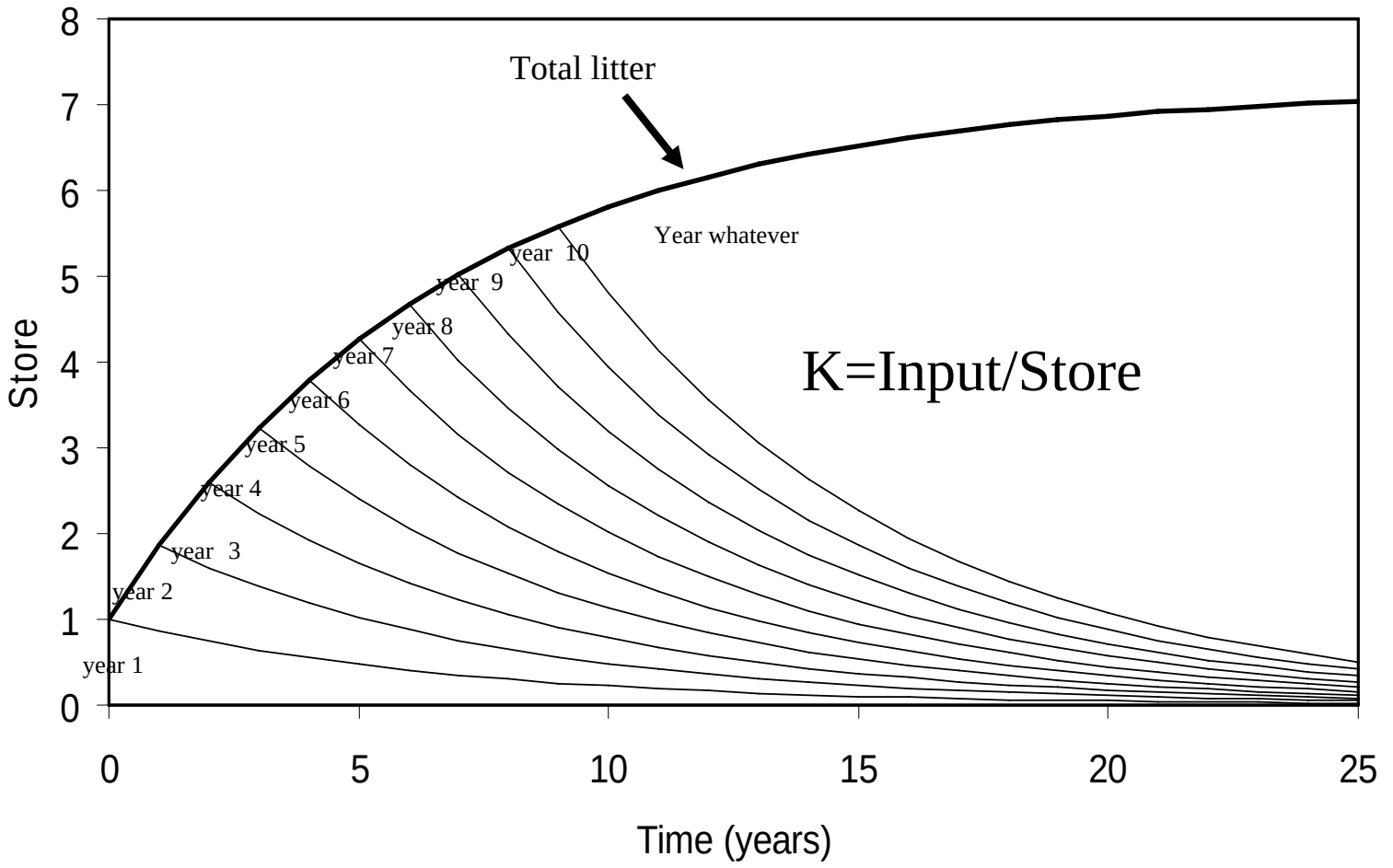
Decomposition rate-constant of slow fraction



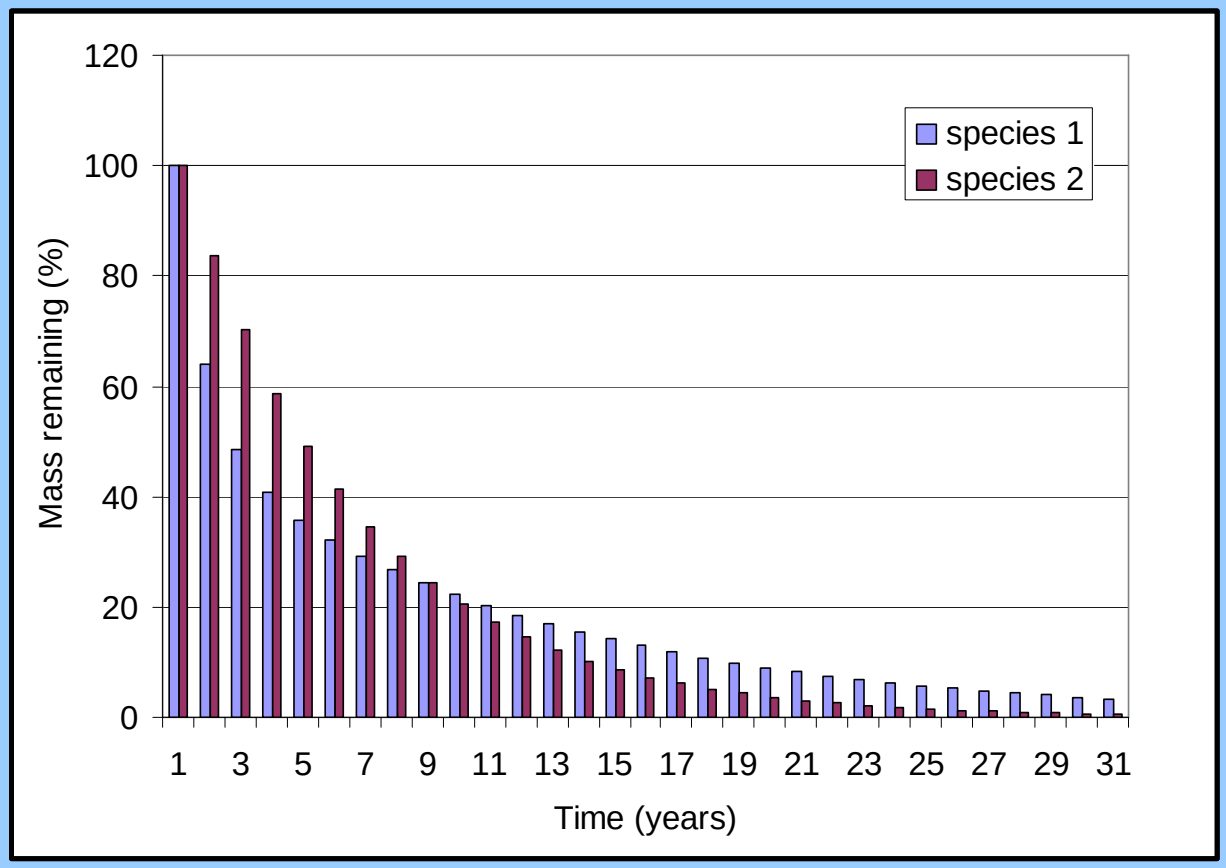
What is the Decomposition Rate?



Overall Decomposition rate-constant: method

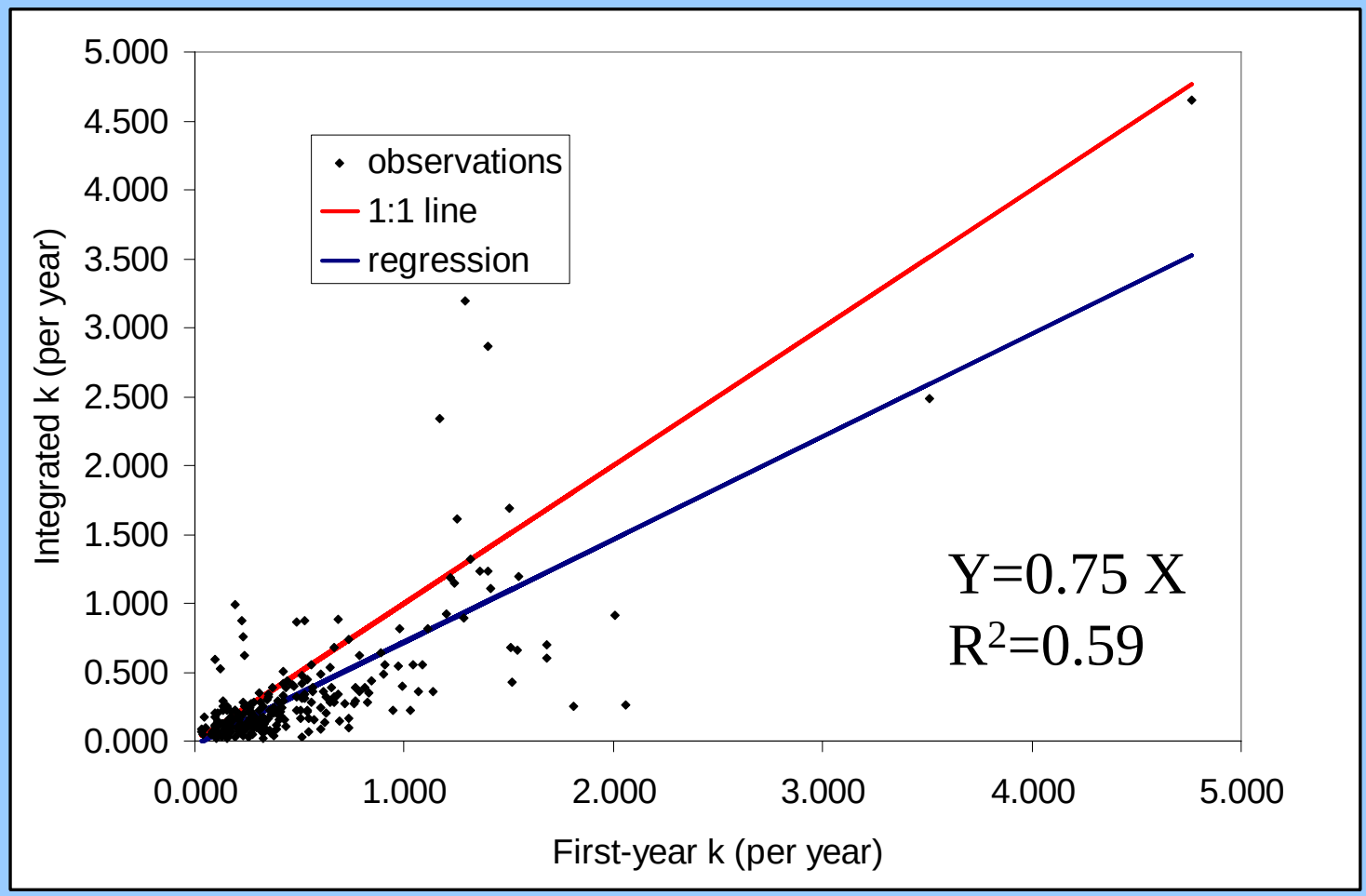


Example of calculation of integrated k

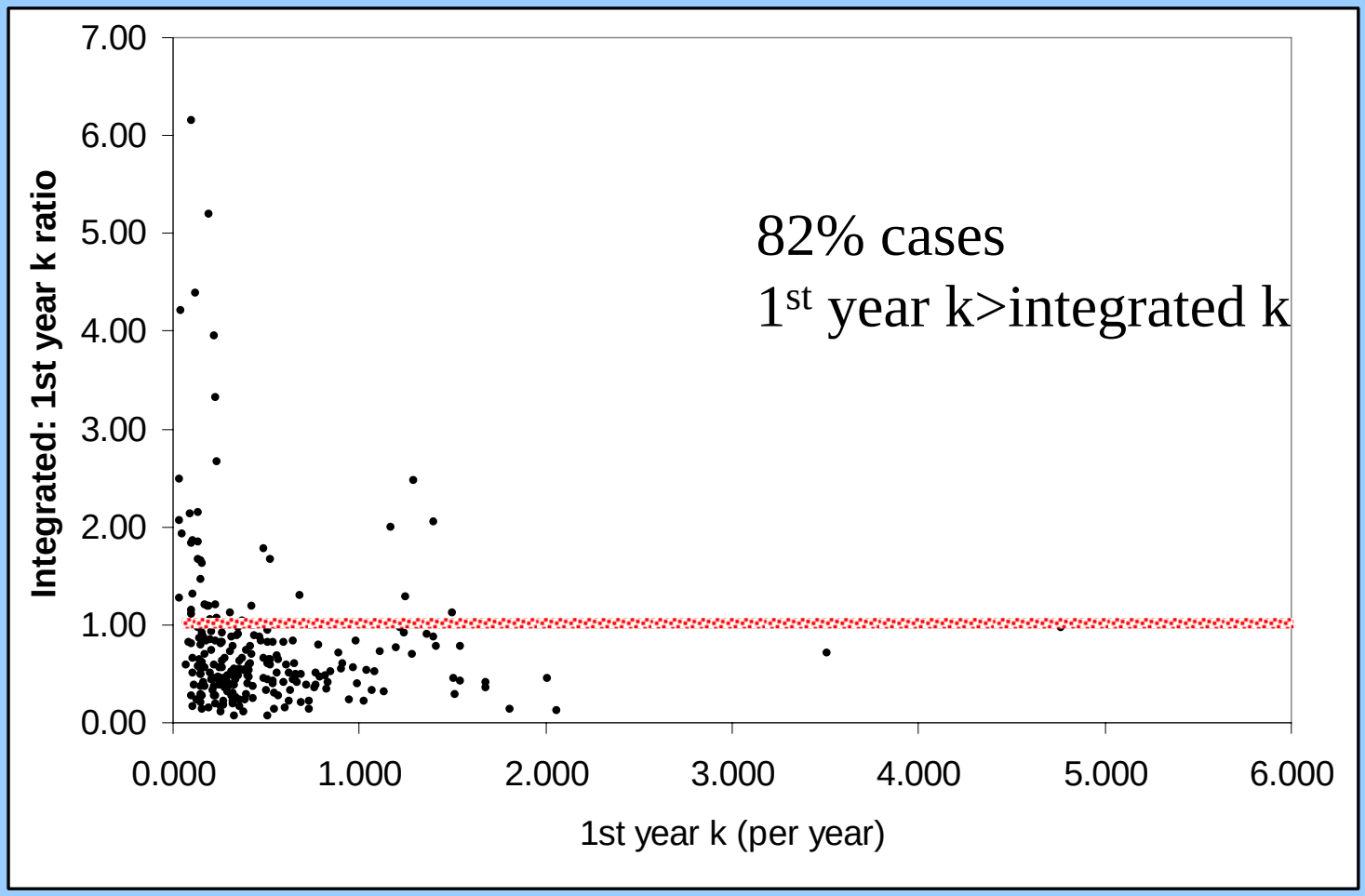


Species	1	2
Store	624	617
Input	100	100
K	0.160	0.162

Integrated v. 1st year k



Integrated v. 1st year k



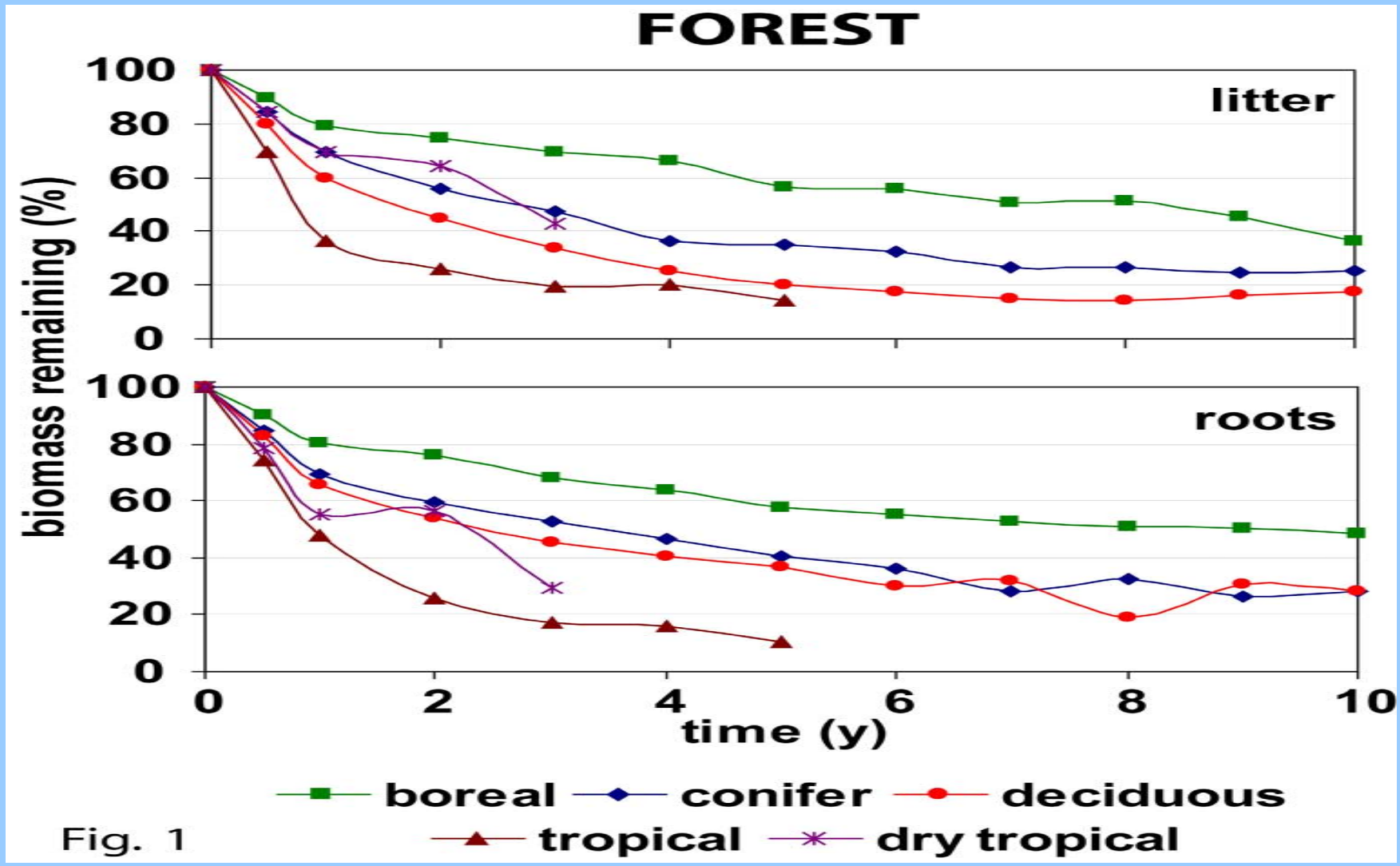


Fig. 1

After Parton et al 2007

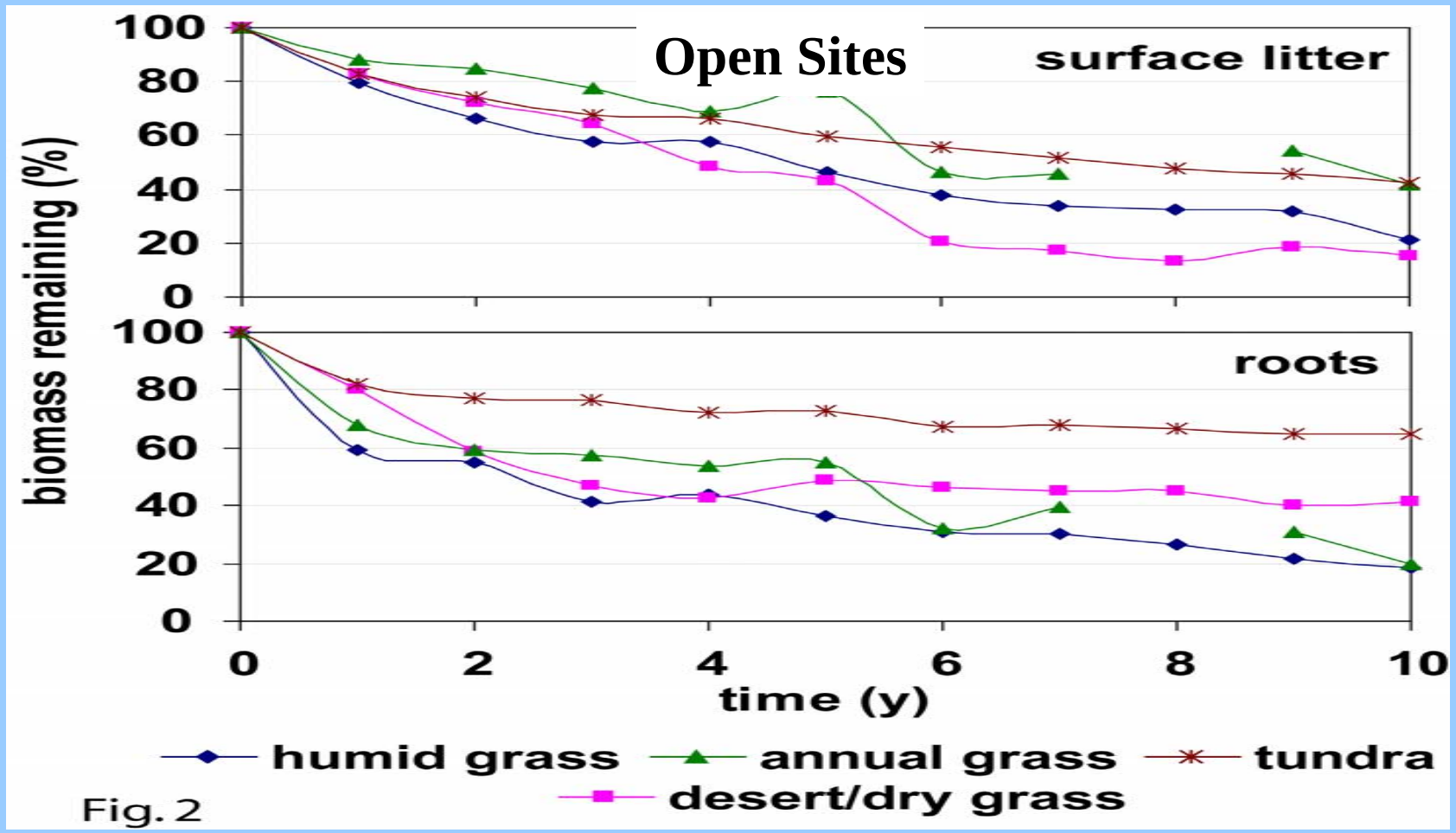
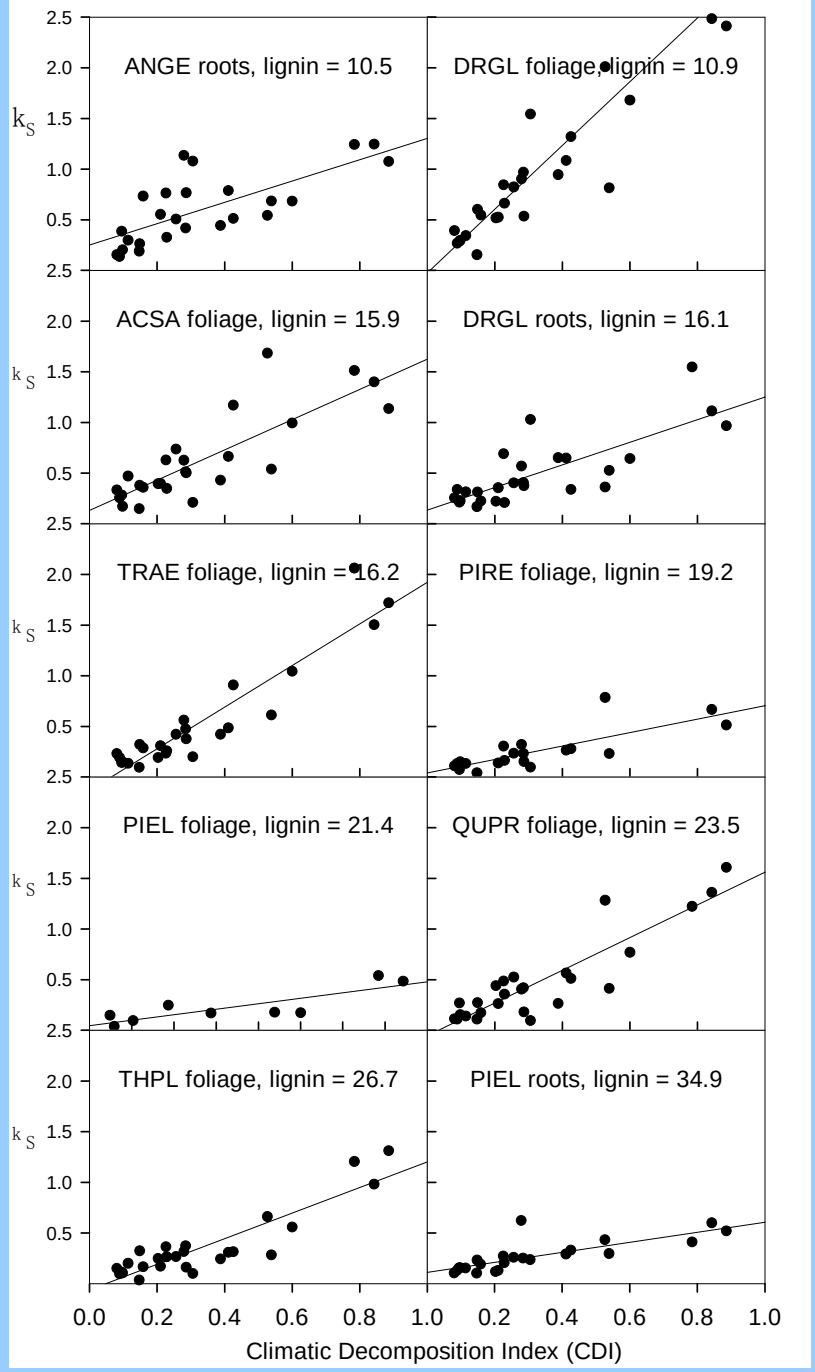


Fig. 2

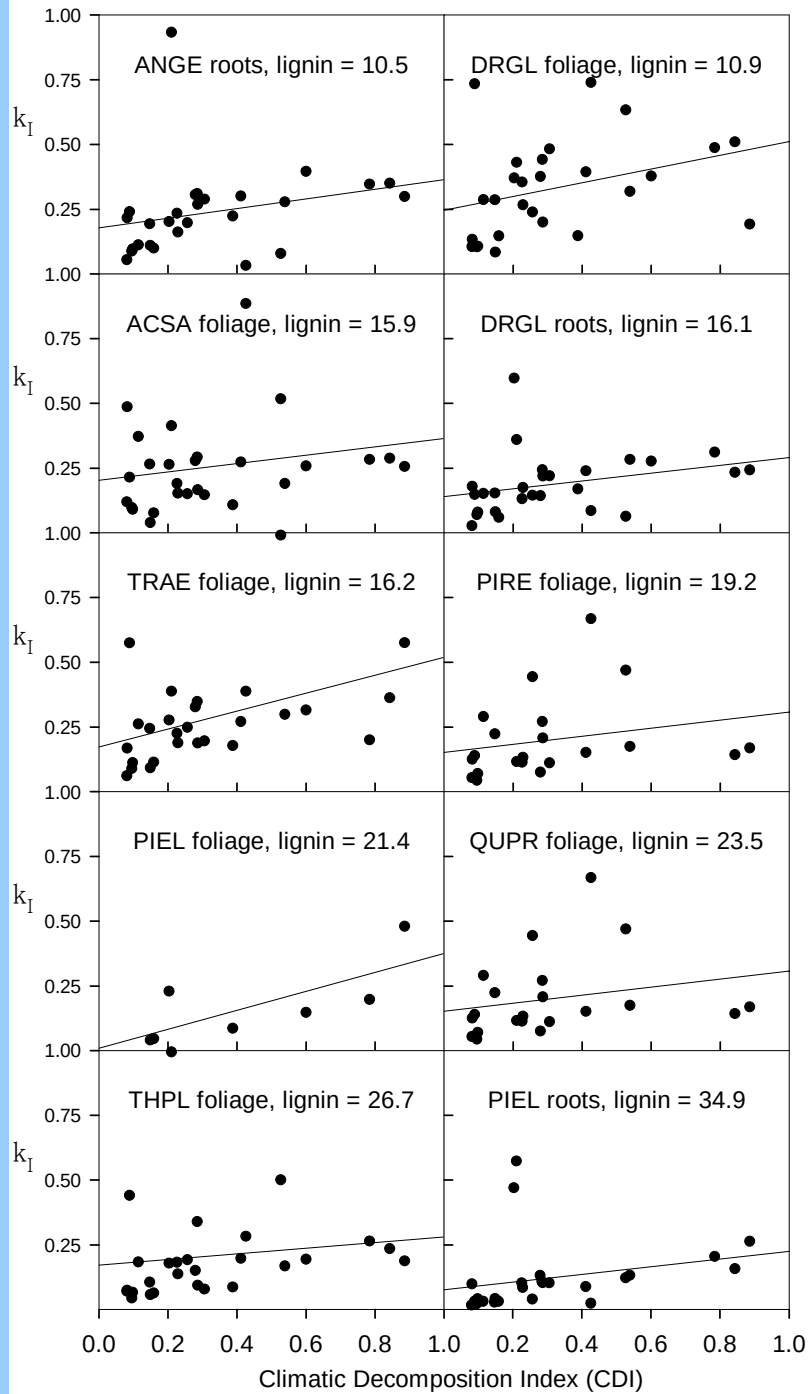
After Parton et al 2007

Short-term relationships 1st year decomposition rate-constants and Climate



Currie et al in prep

Long-term relationships 10 year average decomposition rate-constants and Climate

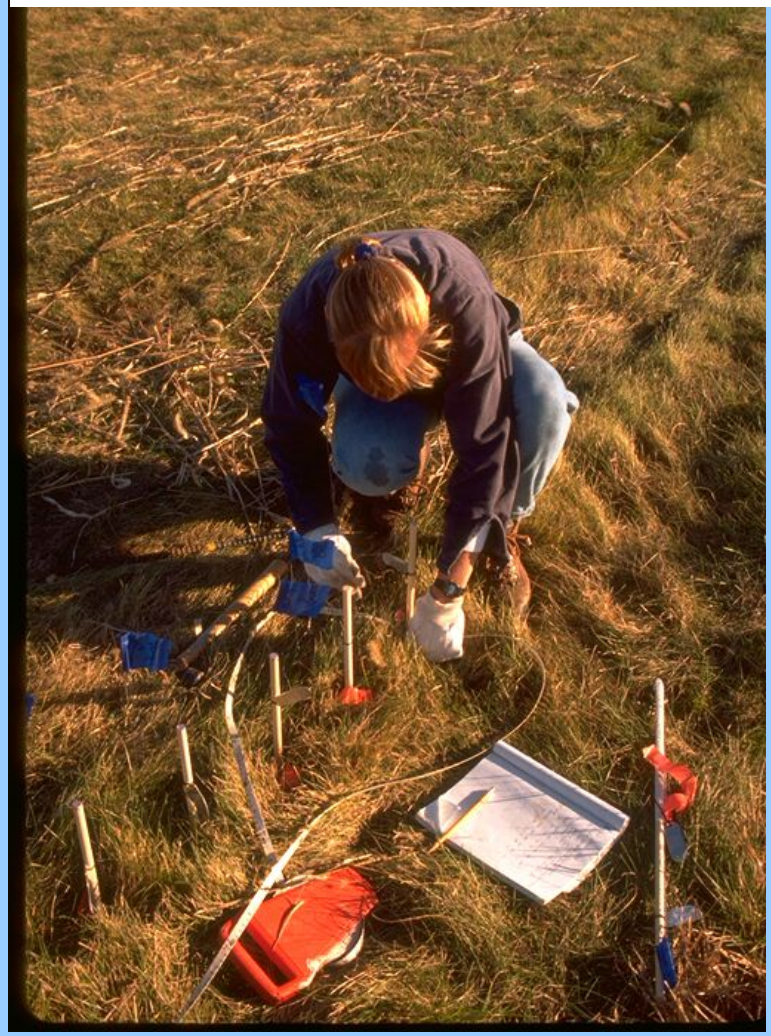


Currie et al in prep

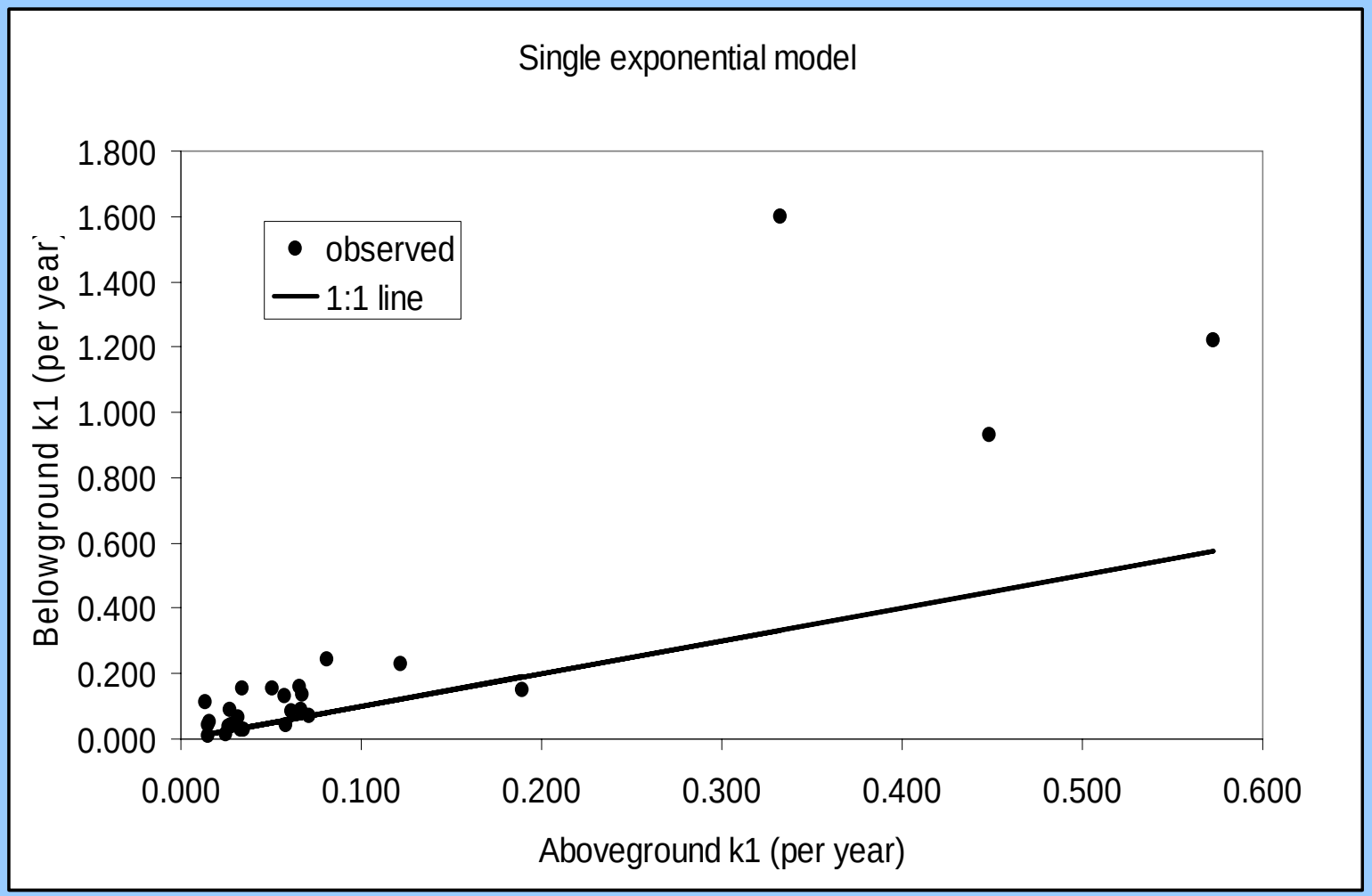
Regression Relationships

Dependent variable	Climate alone			Litter quality alone			AET and lignin only	
	Best independent variable	r^2	p	Best independent variables‡	r^2	p	r^2	p
k_S	CDI	0.46	< 0.001	lignin:N	0.14	< 0.001	0.48	< 0.001
k_H	CDI	0.45	0.048	lignin:N, ascarb, ws	0.11	0.001	0.41	0.001
k_D	CDI	0.30	0.034	lignin:N, ascarb	0.09	0.014	0.28	< 0.001
M_D	CDI	0.11	< 0.001	tnn, acid	0.10	< 0.001	0.16	< 0.001
k_I	AET	0.07	< 0.001	tex, ascarb	0.06	< 0.001	0.13	< 0.001

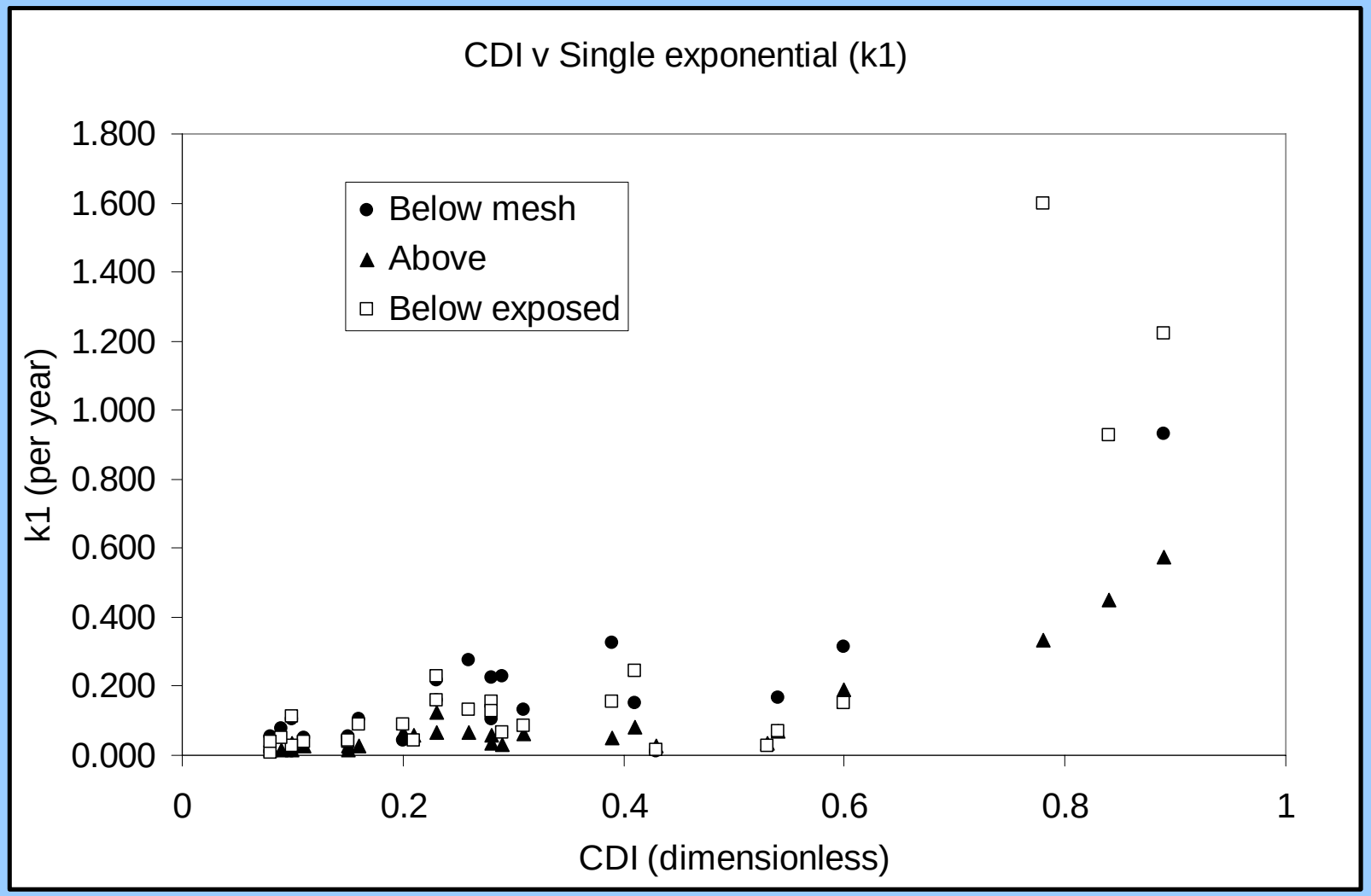
Climatic Effects: Dowel Results



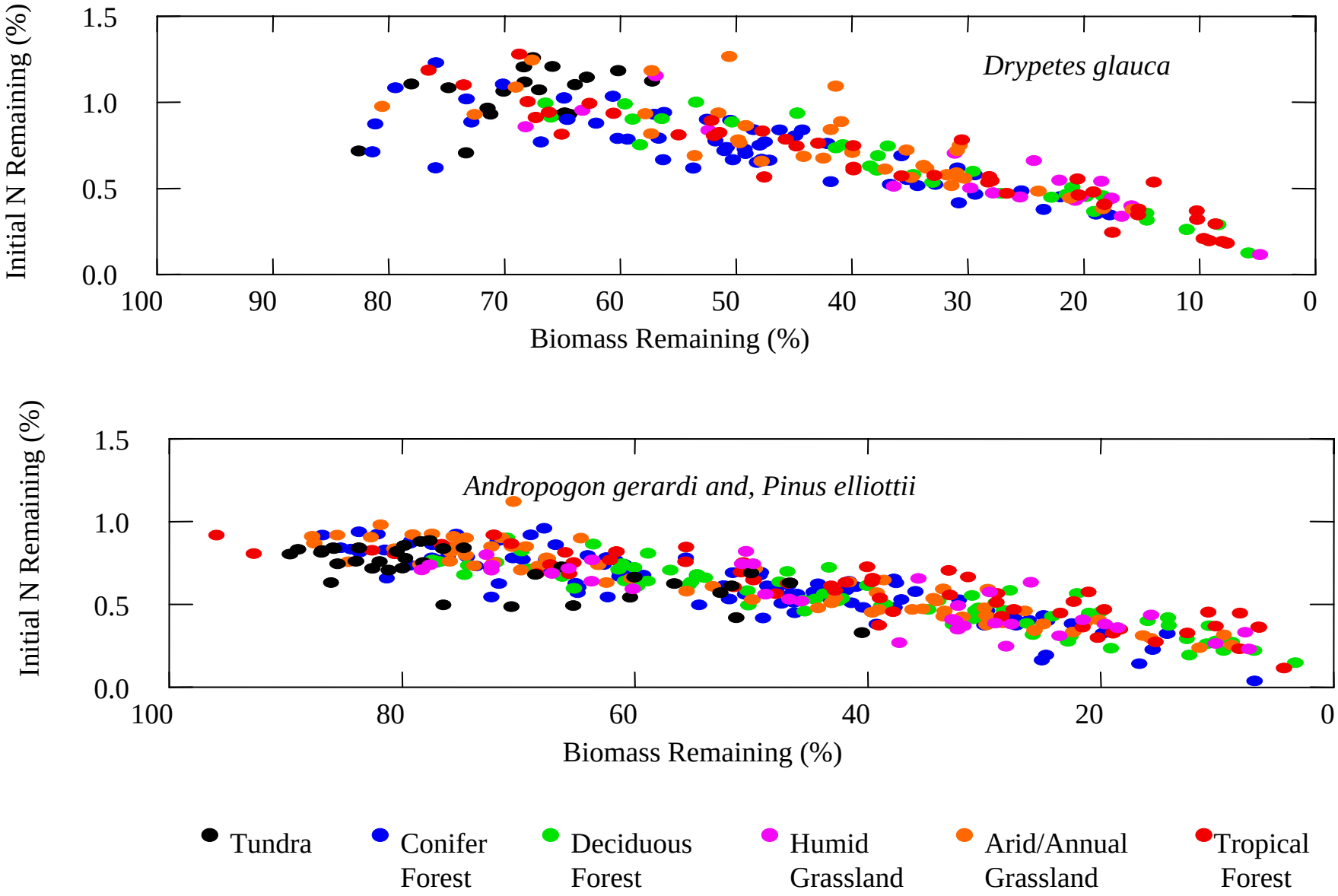
Above- v Belowground



Climate Decomposition Index



Long-term Nitrogen Dynamics-fine roots-Parton et al 2007



Long-term Nitrogen Dynamics-Initial Nitrogen Content-Parton et al 2007

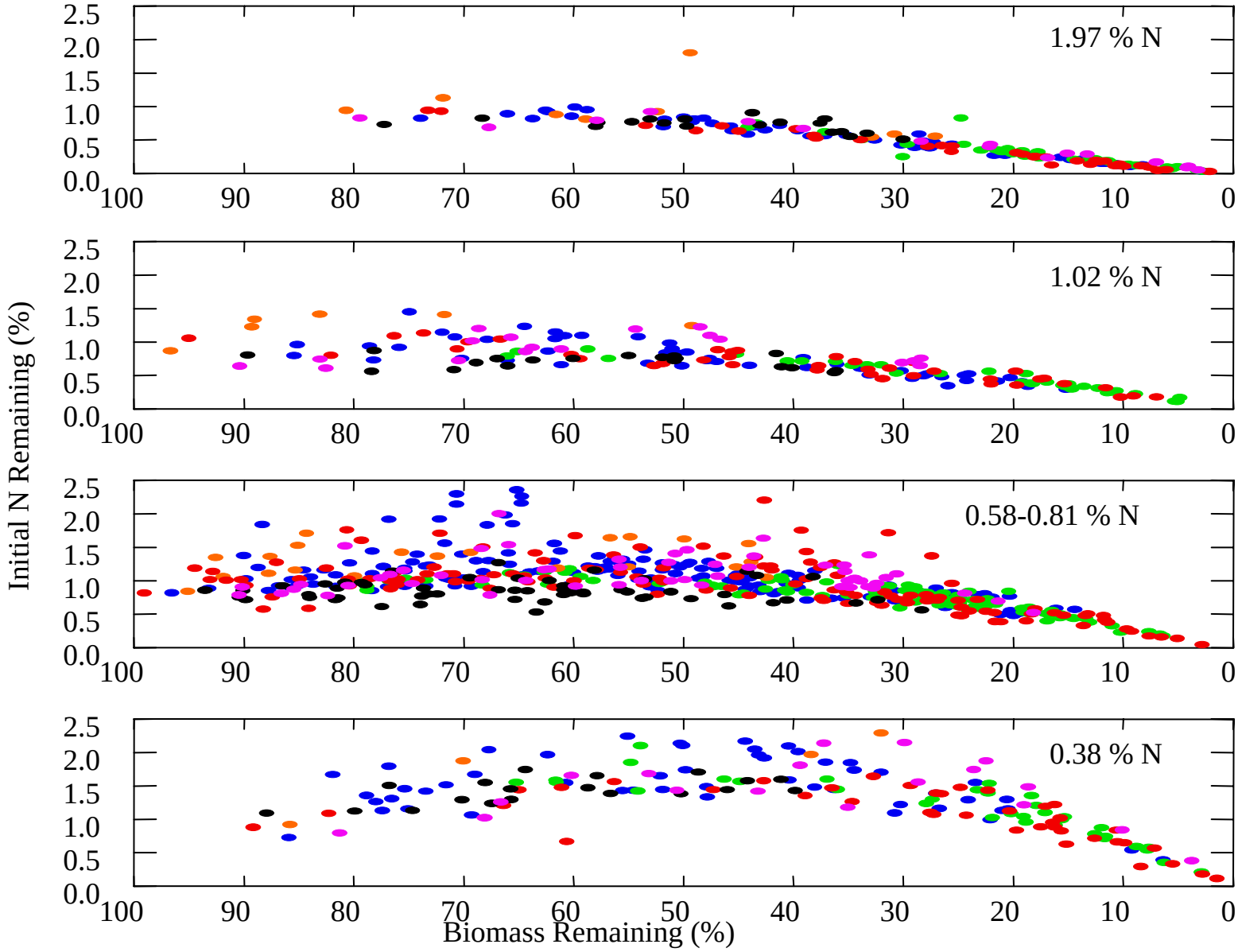
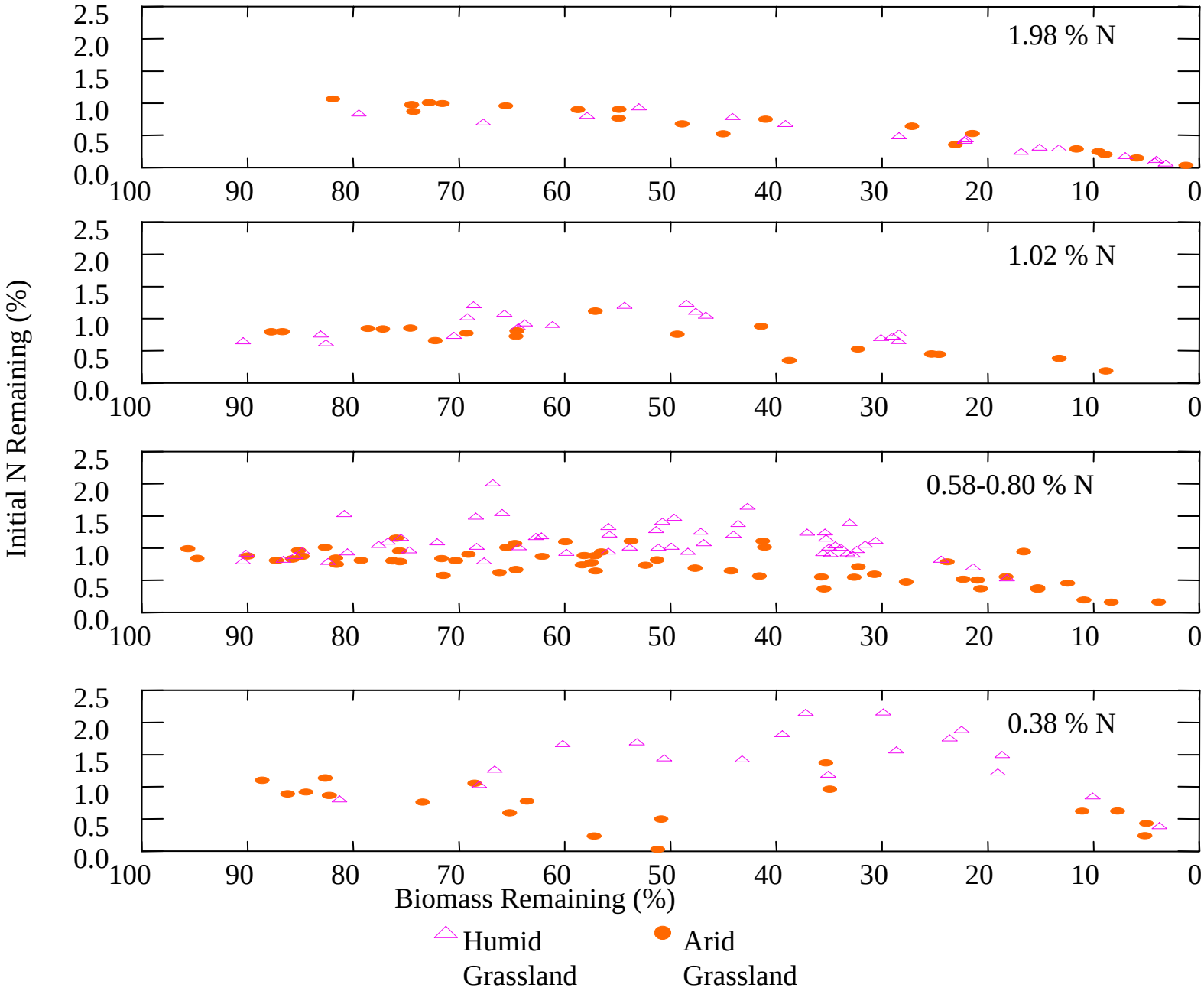


Figure 4 e-h


1.98 % N
1.02 % N
0.58-0.80 % N
0.38 % N
Initial N Remaining (%)
Biomass Remaining (%)
Humid Grassland
Arid Grassland

LIDET

(Long-term intersite decomposition experiment team)

Meeting the challenge of long-term, broad-scale ecological experiments

Understanding ecological systems on the global scale will require an increase in preplanned, long-term, multi-site studies. This page describes an example of this type of research- a 10-year, 28-site experiment to test the effect of substrate quality and macroclimate on long-term decomposition and nutrient dynamics.

The last litter bag collected at HJ Andrews was tag number 1

Long-term intersite decomposition experiment team (LIDET)

Chemical Properties of Undecayed Leaf Litter

Click on Scientific name below to access individual species photo and data

Or click here to access currently available data

1. Abies concolor (ABCO) (Blodgett State Forest)
2. Abies lasiocarpa (ABLA) (Loch Vale)
3. Acer saccharinum (ACSA) (Hubbard Brook)
4. Ammophila breviligulata (AMBR) (Virginia Coast)
5. Andropogon gerardii (ANGE) (Konza)
6. Andropogon scoparius (ANSC) (Konza)
7. Betula lutea (BELU) (Harvard Forest)
8. Bouteloua gracilis (BOGR) (Central Plains)
9. Ceanothus greggii (CEGR) (Santa Margarita)

Chestnut Oak *

Collected from Coweeta

*part of the LIDET study

Source	Ash %	Carbon %	Nitrogen %	Lignin %	Tannin %	NPE %	WS %
Wet Chem.	4.39	51.48	1.03	23.51	6.88	9.35	27.22
NIR	n/a						

Return to species list

Long-term intersite decomposition experiment team (LIDET)

LIDET Study Supplies and Procedure

We get plenty of questions regarding our methods.
Here are the answers to the most common questions.

Supplies:

Our Litter Decomposition studies use the mesh available from the Nylon Net Company (www.nylonnet.com) Knotless Netting - Delta 35 lb. test - 1/32" in either 4 foot (D1324) or 8 foot (D1328) widths. This mesh is approximately 1 mm mesh.

For the bottoms of our litterbags we used white polyester broadcloth to minimize loss through sifting through the mesh. This material has approximately 55 micron mesh, and is commonly available in fabric stores. We do not wash either the mesh or the broadcloth prior to use.

We sew our bags with polyester core cotton covered thread that is commonly available in fabric stores here, leaving one end open for filling.

The final closure is made with non-ferrous Monel staples which will not corrode.
They are available from:

HJ Andrews Experimental Forest

Long Term Ecological Research

TD023

LTER Intersite Fine Litter Decomposition Experiment (LIDET)

- **PI:** Mark E. Harmon
- **Originator:** Mark E. Harmon
- **Other researchers:**
- **Dates of study:** Aug 15 1990 - Jan 1 2002
- **Data access:** Online
- **Last Update:** May 3 2005 (Version 3)

<Citation> <Acknowledgement> <Disclaimer>

ABSTRACT: Full Abstract

The primary objective of this study is to examine the control that substrate quality and climate have on patterns of long-term decomposition and nitrogen accumulation in above- and below-ground fine litter. Of particular interest will be to examine the degree these two factors control the formation of stable organic matter and nitrogen after extensive decay.

ENTITY TITLES:

Future Experiments

Fill out range of environments: Tropical-subtropical; hydric

Better Understanding of Microclimate

Influence of organisms

Decomposition rate of the slow phase material

Does mass of slow phase depend on formation rate or decomposition rate?