Long-term organic carbon turnover rates in natural and semi-natural topsoils

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RTE Mills et al
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climate

litter type

N, P

texture

SOM
(Soil Organic Matter)
turnover

C storage
& exchange

other
soil functions

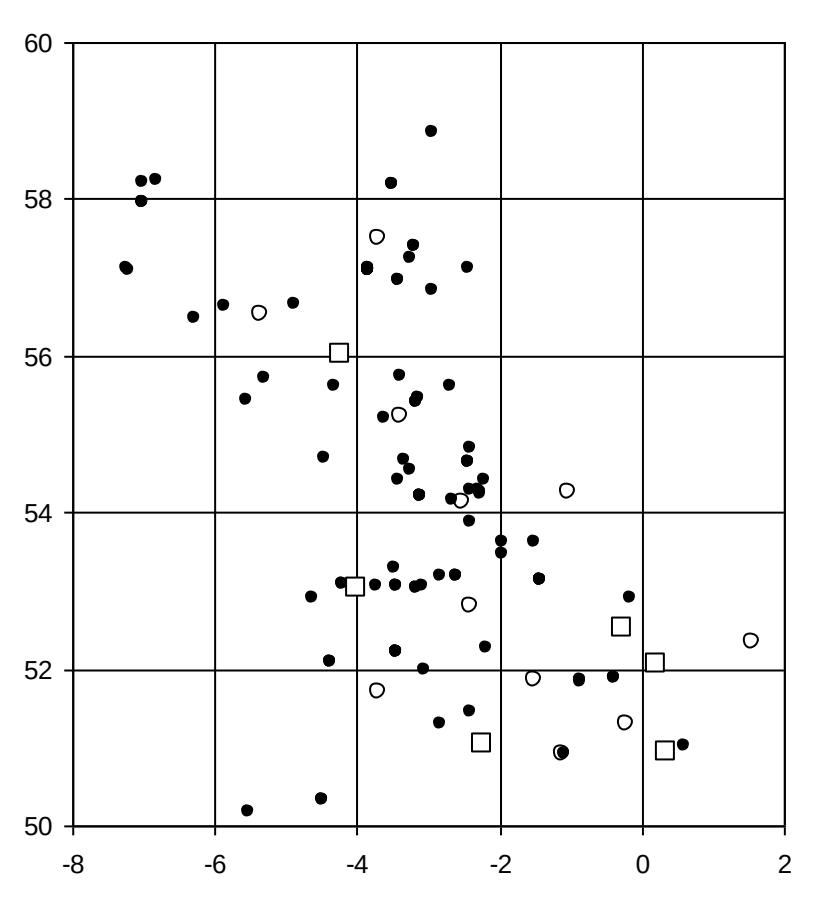
What are the global rates?

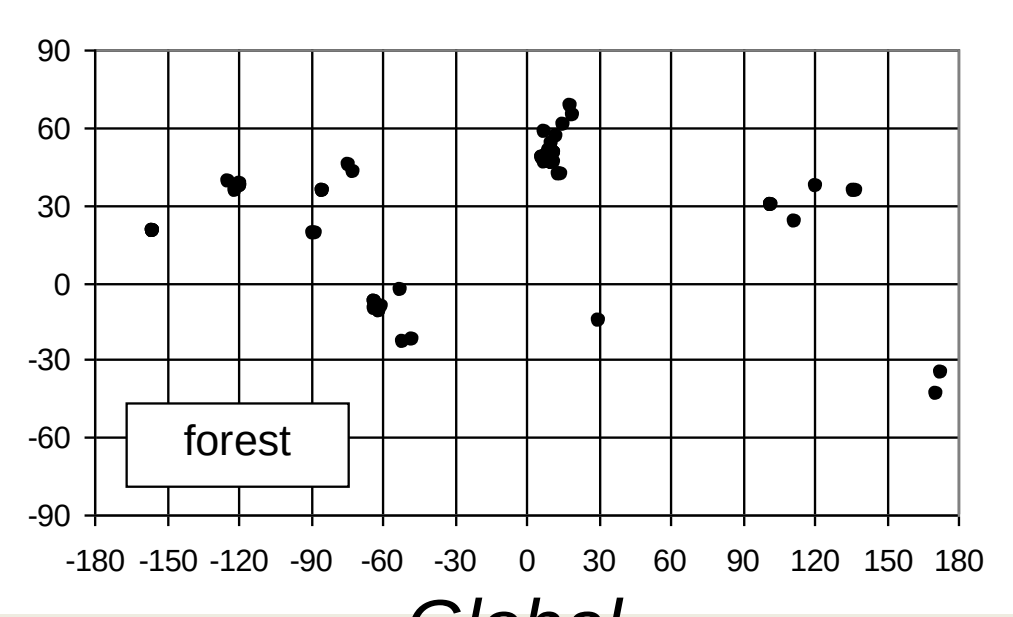
Is there a difference between forest and non-forest soils?

Can we explain variability?

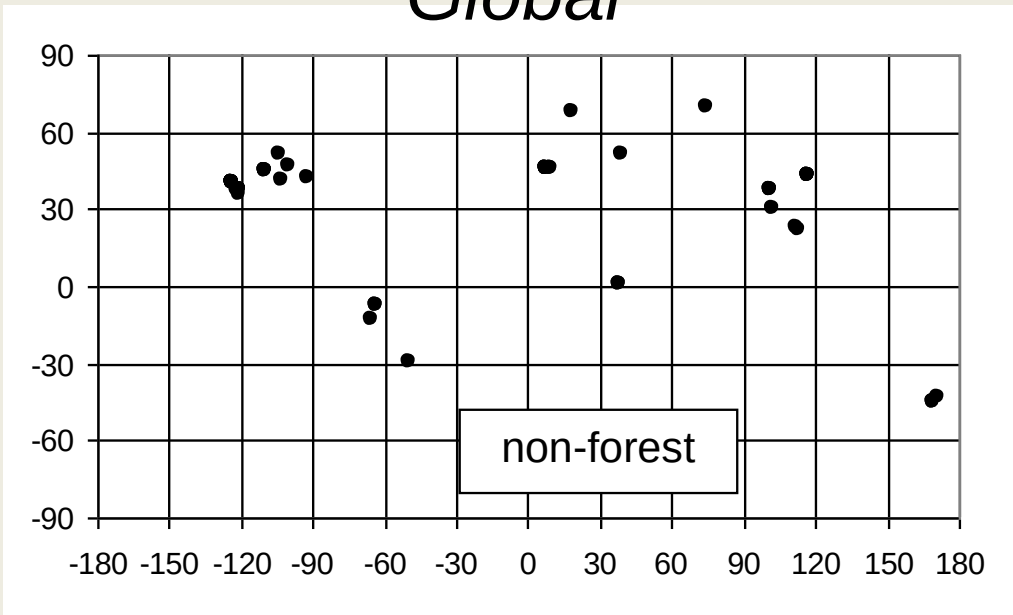
Geographical distributions of sites

Britain





Global



Comparing ^{14}C contents of topsoils (~15 cm) over time

	forest			non-forest			
	n	^{14}C	SD	n	^{14}C	SD	p
1947-1962	6	94.7	1.1	6	91.5	1.7	>0.05
1970-1978	28	111.3	1.2	6	106.1	3.4	>0.05
1990-1998	27	111.5	0.9	21	104.8	2.2	<0.02
2000-2004	43	110.2	0.8	26	100.8	1.3	<0.001
2005-2008	22	107.4	1.3	98	100.7	0.8	<0.001

Forest soils are richer in bomb carbon

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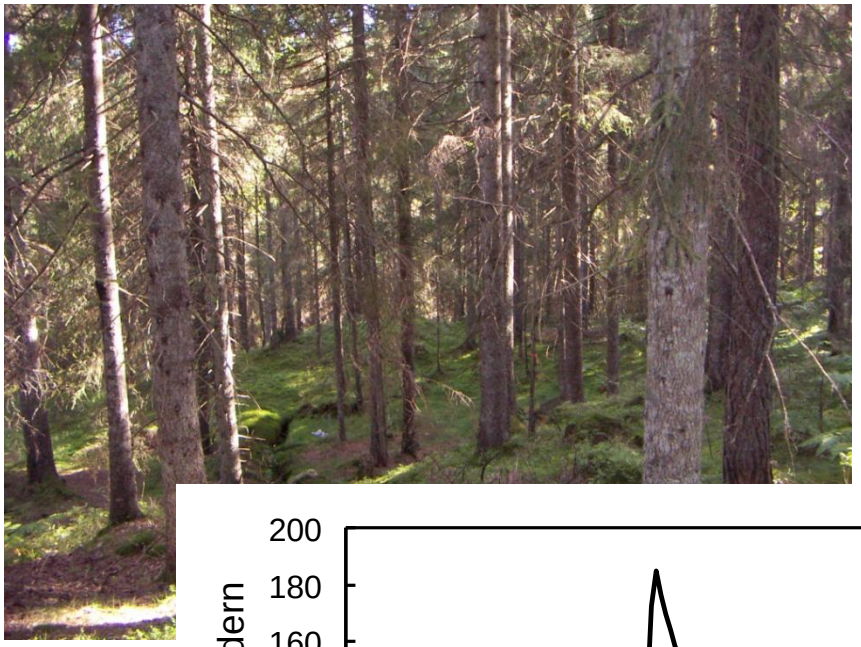
Spruce forests, Sweden

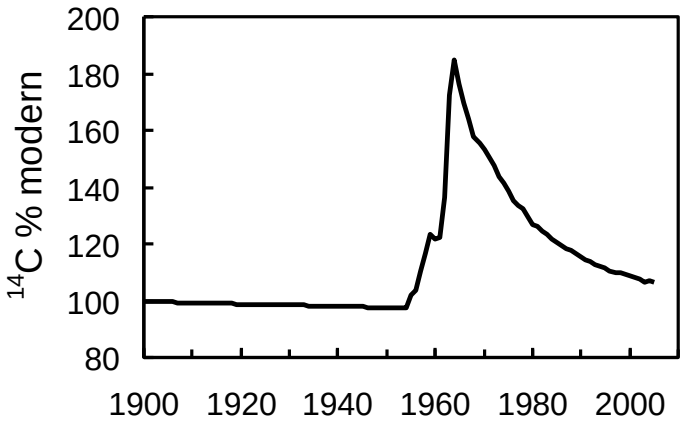
<u>O-horizon</u>

C pool ~ 2000 gC m^{-2}

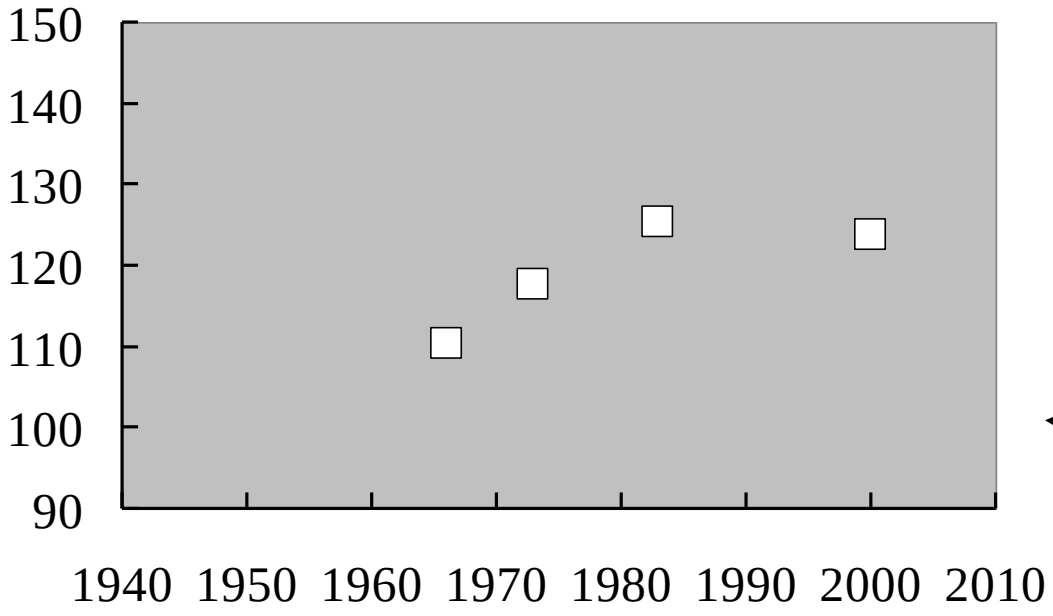
Litter input ~ 200 gC m^{-2} a^{-1}

Steady-state MRT = 10 years



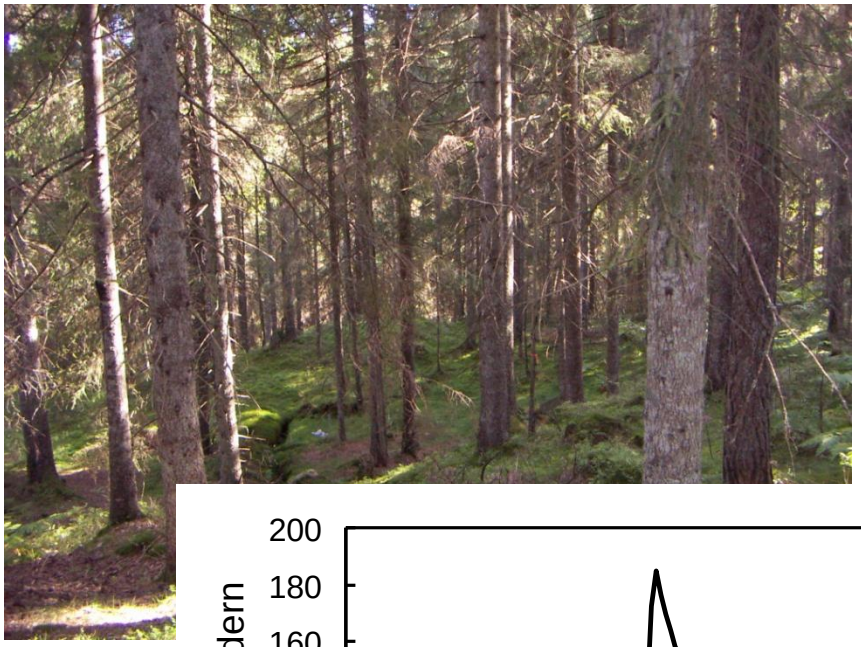


^{14}C data (M Fröberg, C Bryant)



5-year delay of ^{14}C in tree

Spruce forests, Sweden



O-horizon

C pool ~ 2000 gC m^{-2}

Litter input ~ **200** gC m^{-2} a^{-1}

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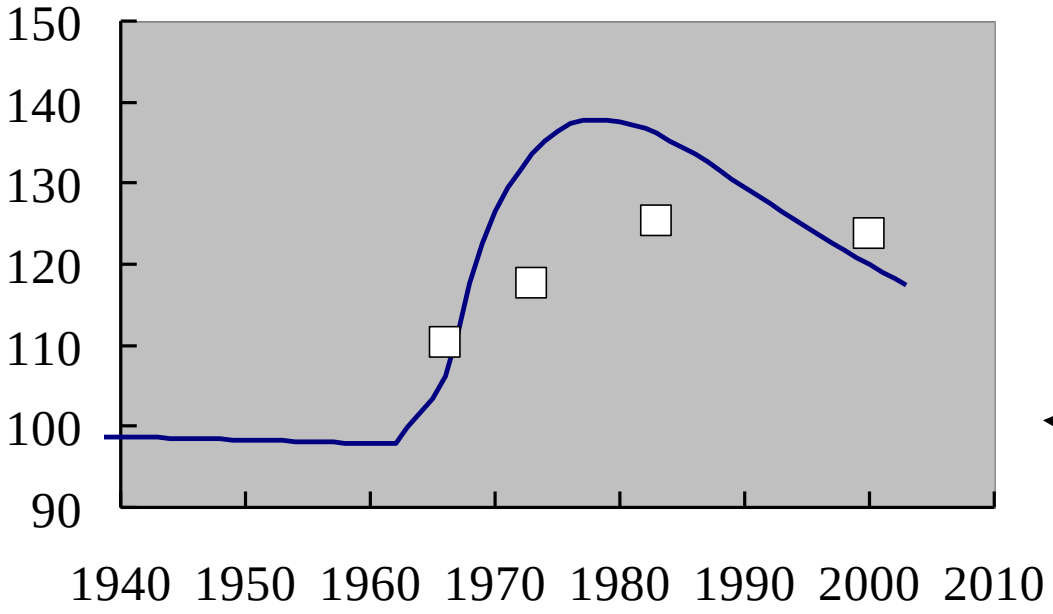
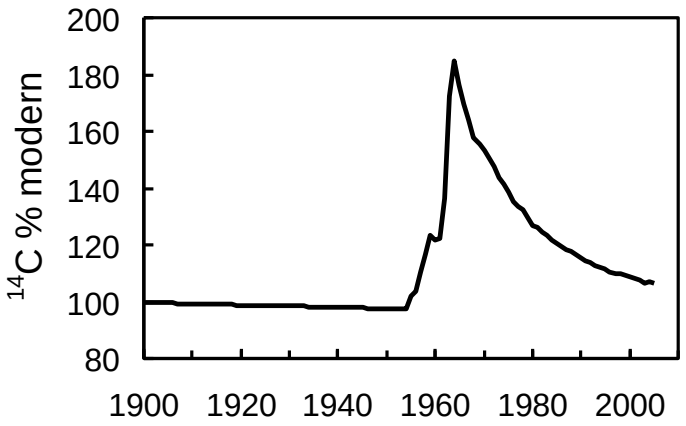
^{14}C data (M Fröberg, C Bryant)





5-year delay of ^{14}C in tree

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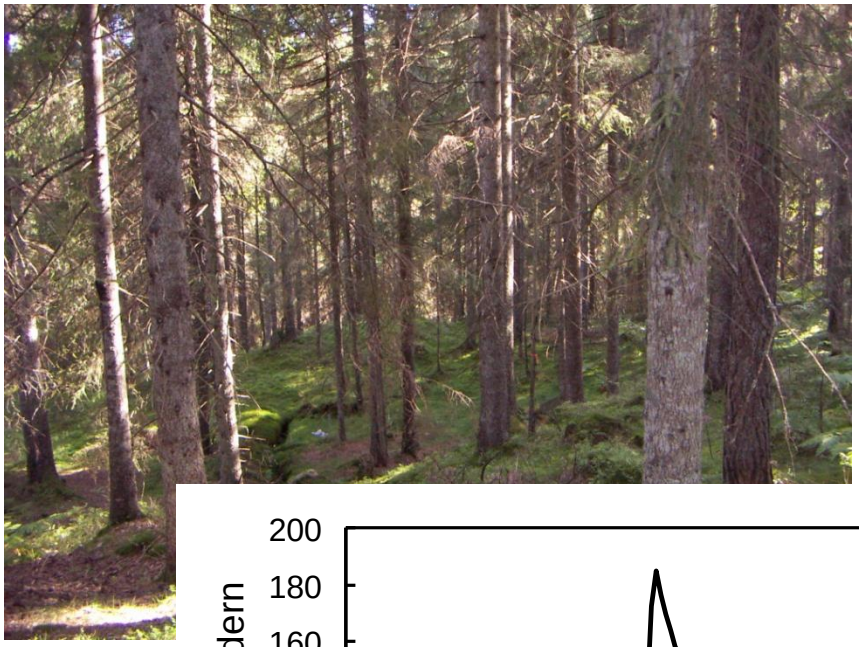


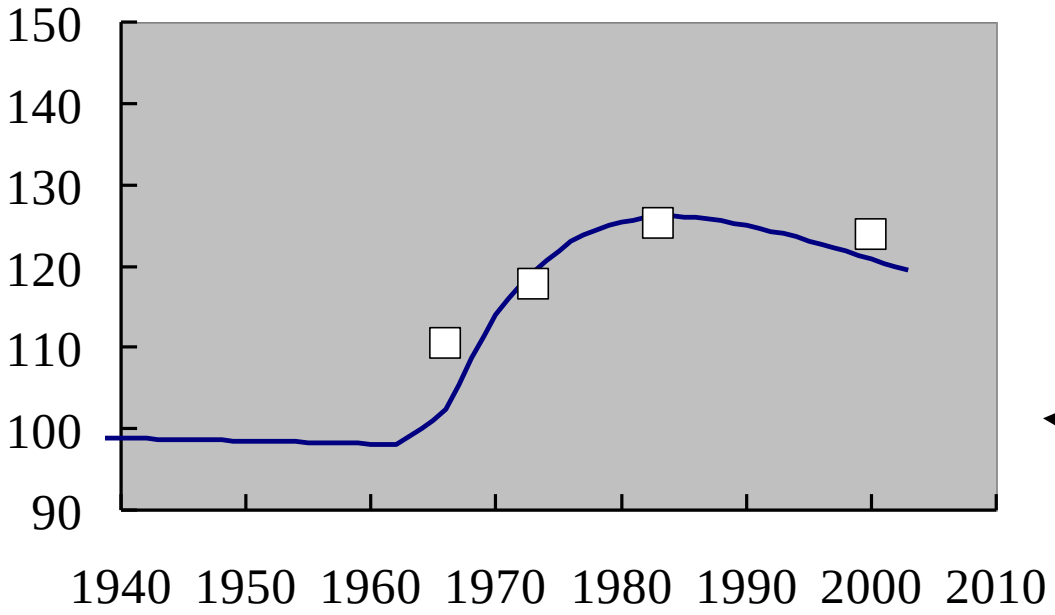
O-horizon

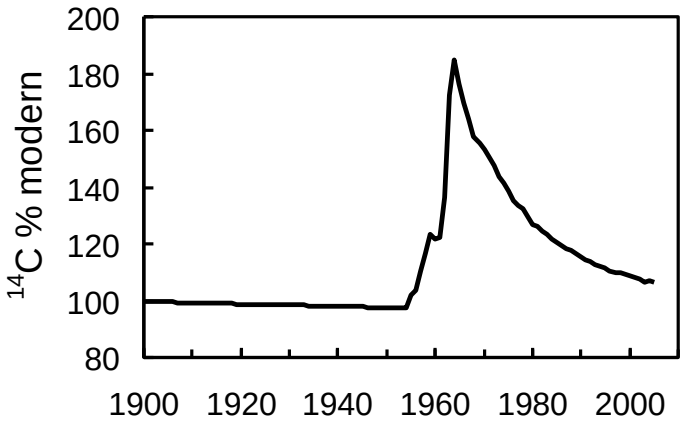
C pool ~ 2000 gC m^{-2}

Litter input ~ **100** gC m^{-2} a^{-1}

Steady-state MRT = **20** years

^{14}C data (M Fröberg, C Bryant)

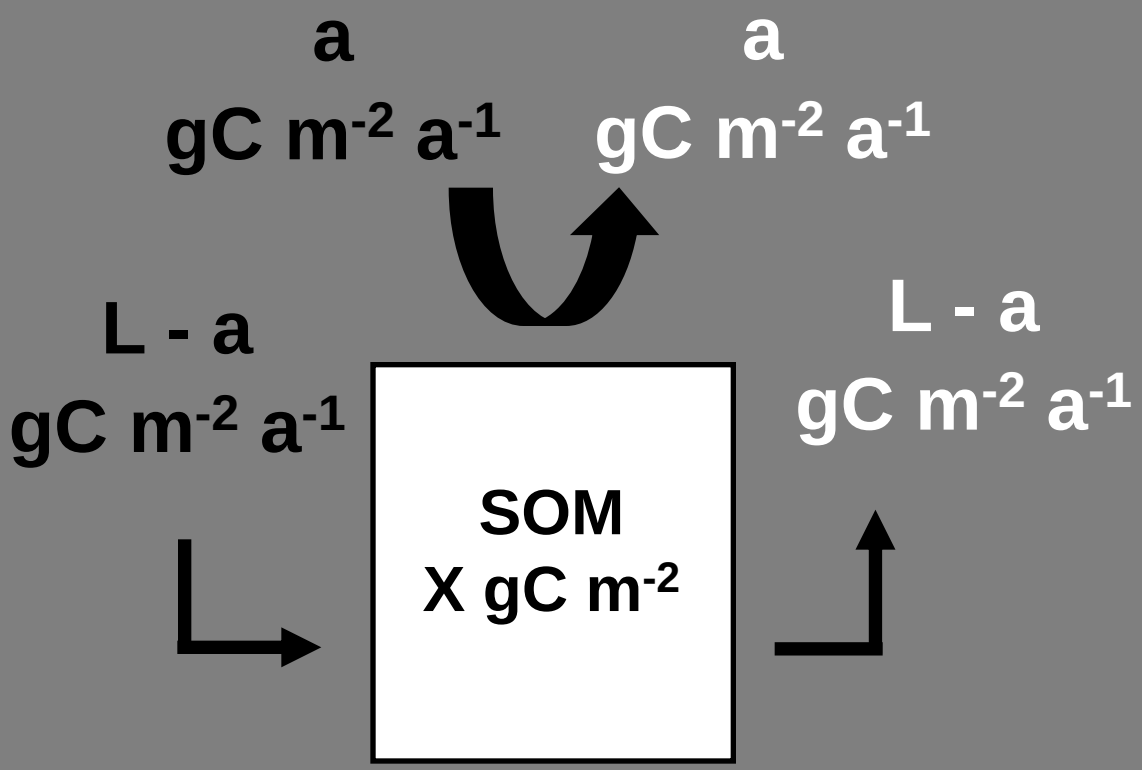




5-year delay of ^{14}C in tree

Steady-state soil carbon model II

- total litter input is **L**
- one homogeneous soil pool, in steady state
- one fast pool



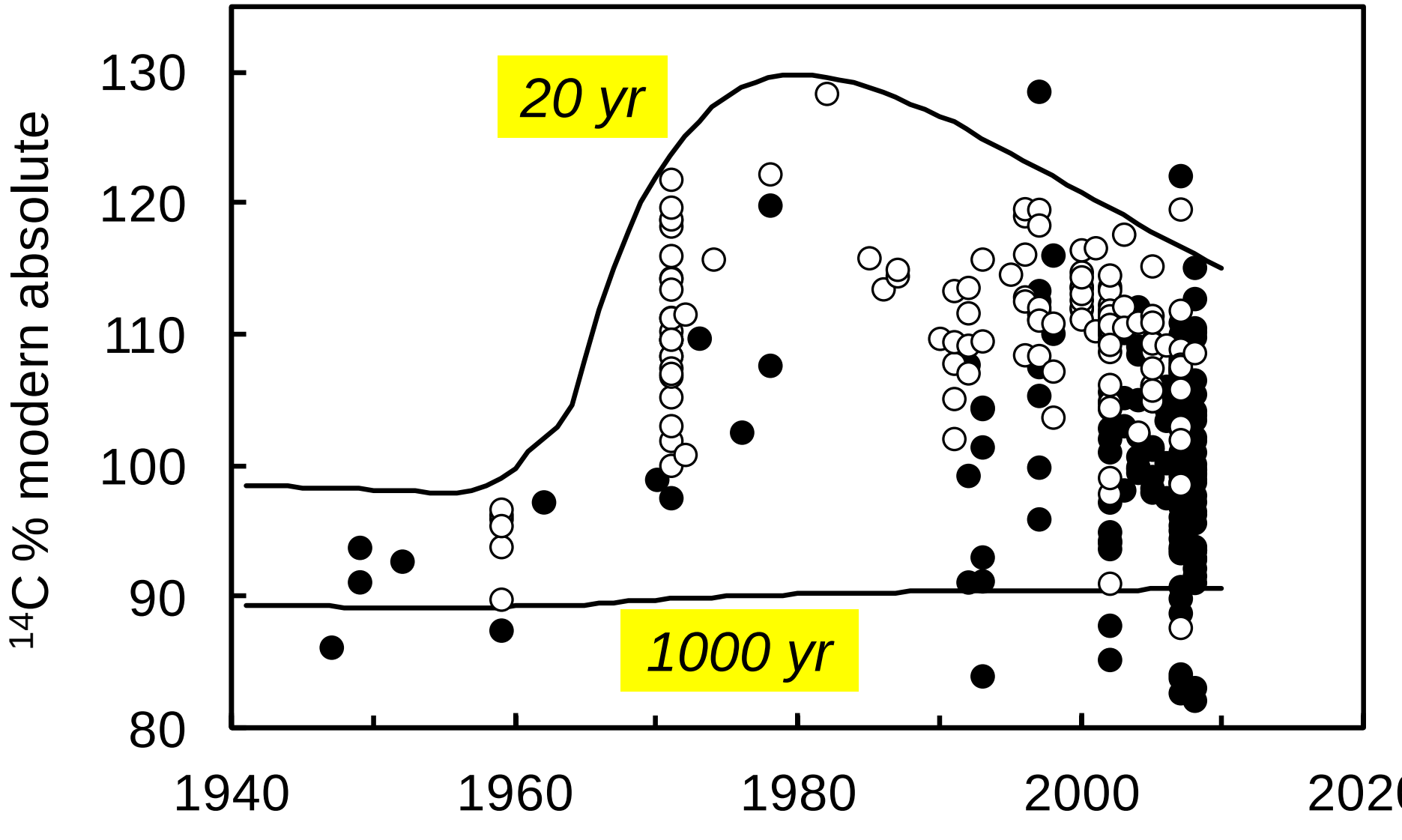
soil MRT =

X / (L-a) years

model fitting of ^{14}C requires adjustment of MRT

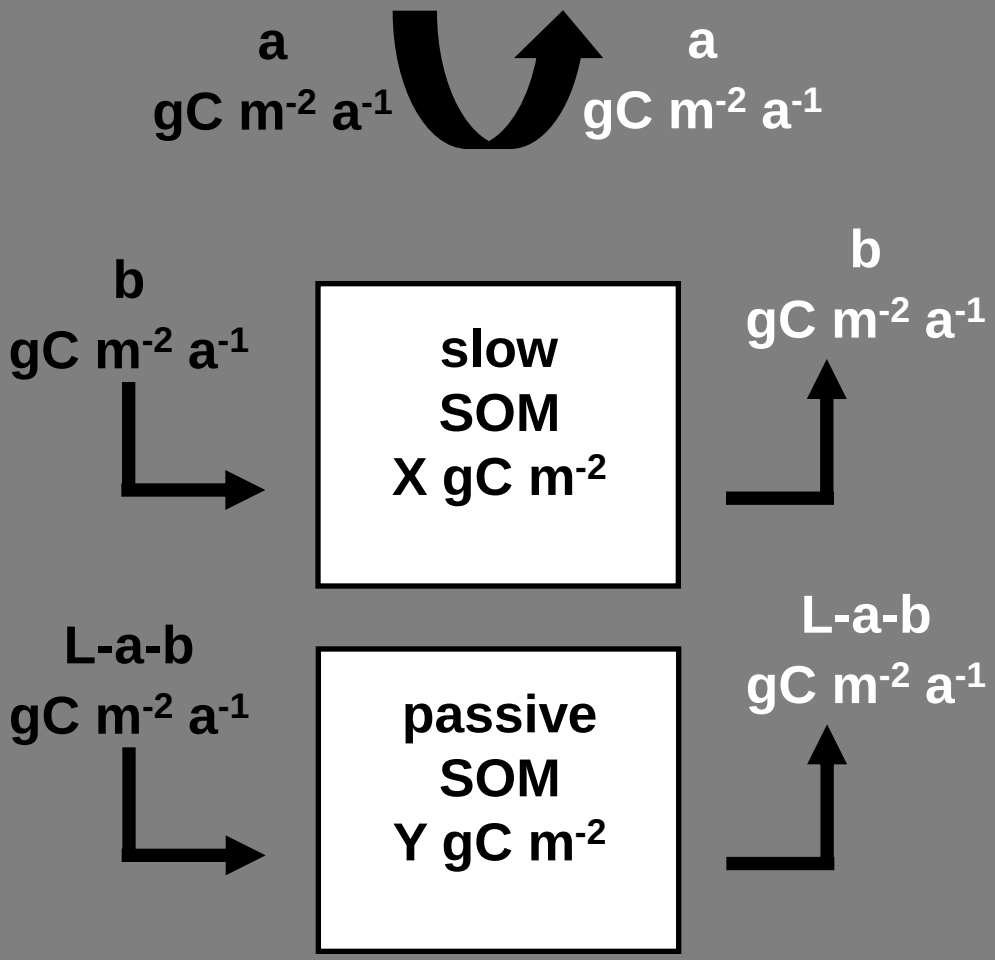
But a single MRT is unrealistic!

250 topsoil ^{14}C values open = forest / closed = non-forest



Steady-state soil carbon model III

- one slow soil pool, one passive soil pool



slow MRT

= X / b

passive MRT

= Y / (L-a-b)

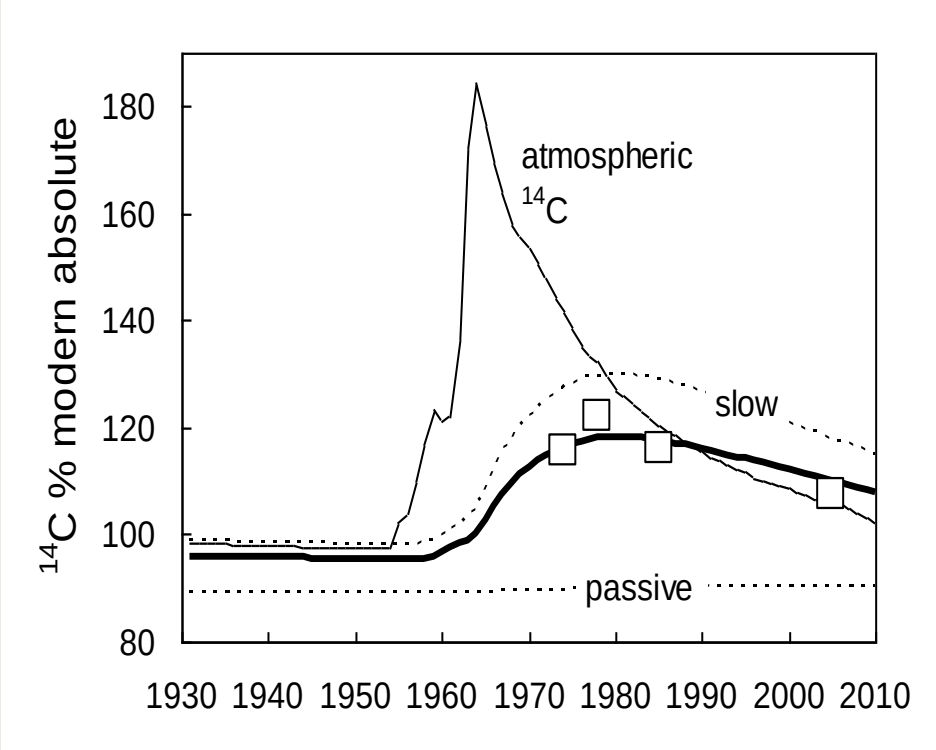
<u>fixed MRTs</u>

slow	**20 yr**
passive	**1000 yr**

model fitting of ^{14}C by adjusting the fraction of slow C

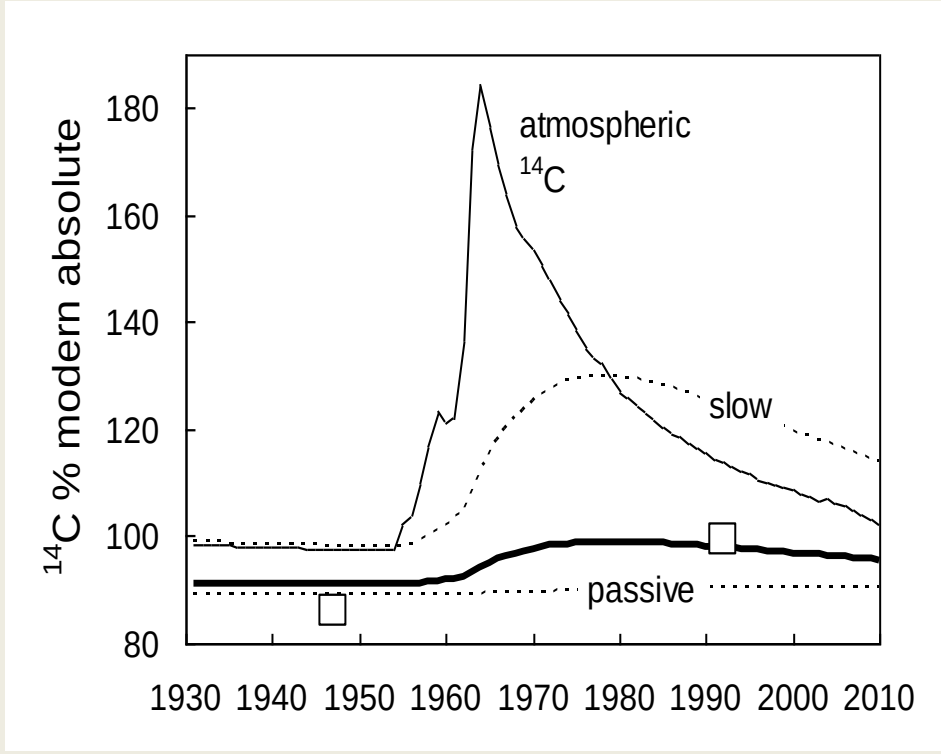
Fitting process – finding the correct slow / passive ratio

forest soil 5.97 kgC m^{-2}



slow fraction 0.71

non-forest soil 4.02 kgC m^{-2}

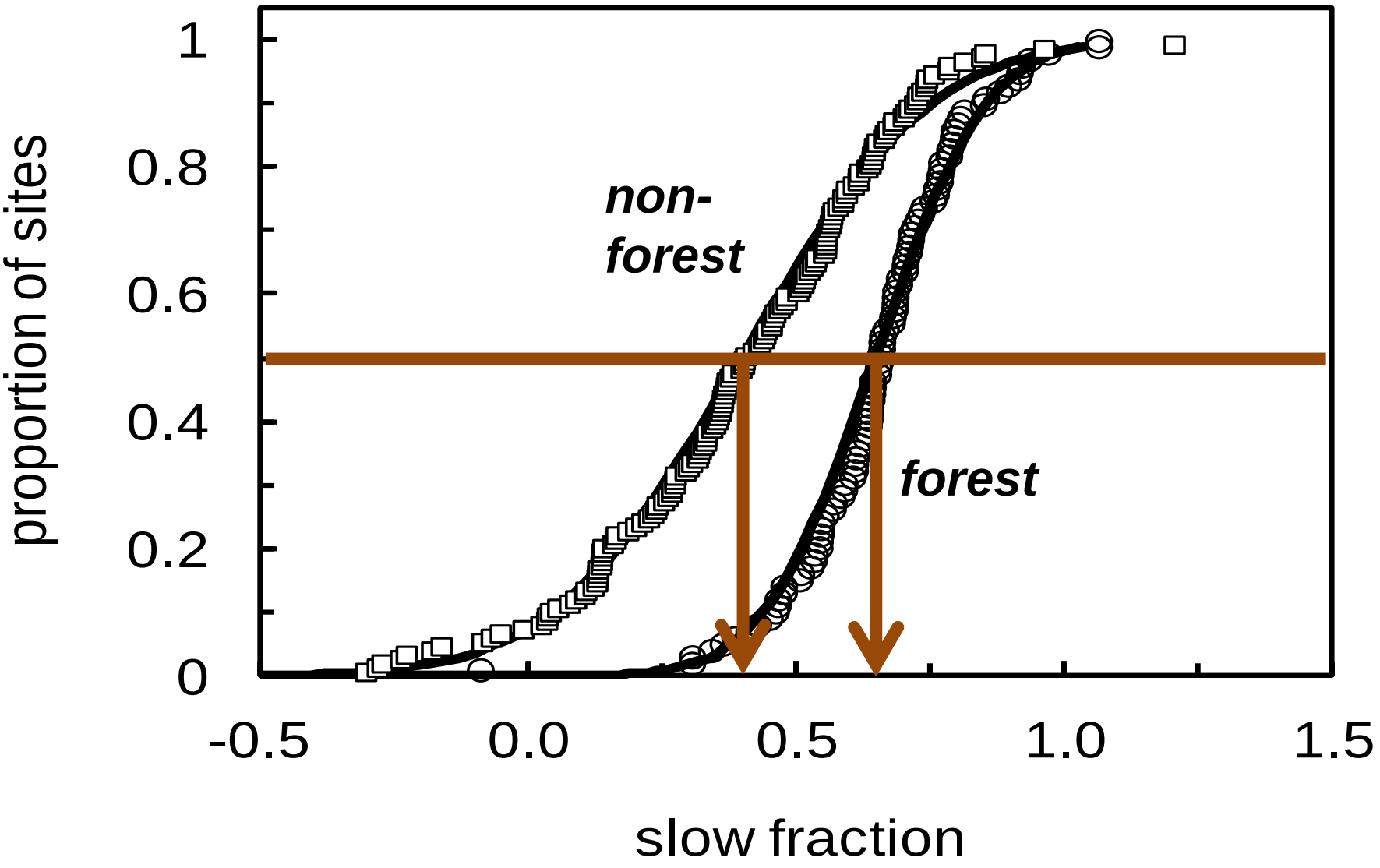


slow fraction 0.23

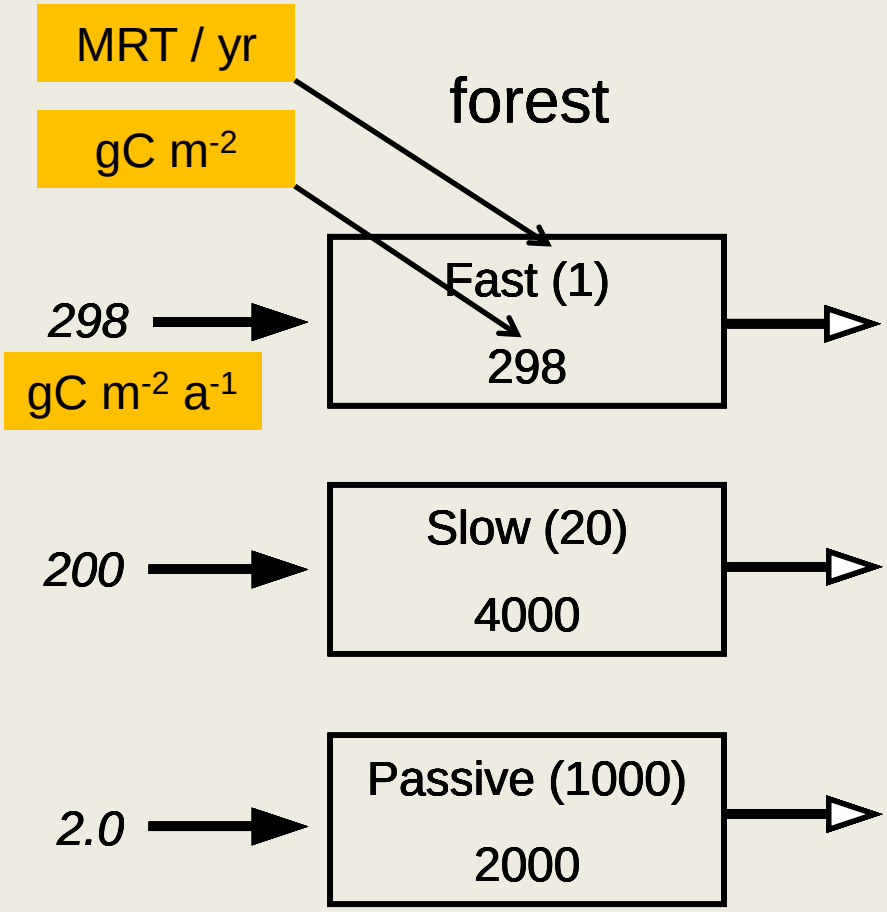
Only one ^{14}C value is needed.

If soil pools are known, can estimate slow and passive pools and fluxes.

251 fitted sites, ordered



Global average topsoil C pools and fluxes



Assuming annual litter input
= 500 gC m^{-2} a^{-1}

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Explaining the variance?

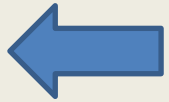
Little dependence on

soil type
mean annual temperature
mean annual precipitation
pH
%C
total C pool

Non-steady-state

black carbon, charcoal
“hot” contamination
land-use change
increased grazing
N deposition
burning
young soil

sensitivity analysis



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Conclusions

- Broad quantitative picture of topsoil carbon turnover
- Overall faster turnover in forest soils
- Wider range in non-forest soils
- No relationships with “obvious” drivers
- Variations may arise from non-steady-state factors

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