Changing relation between CO_2- and water fluxes in Swiss forests

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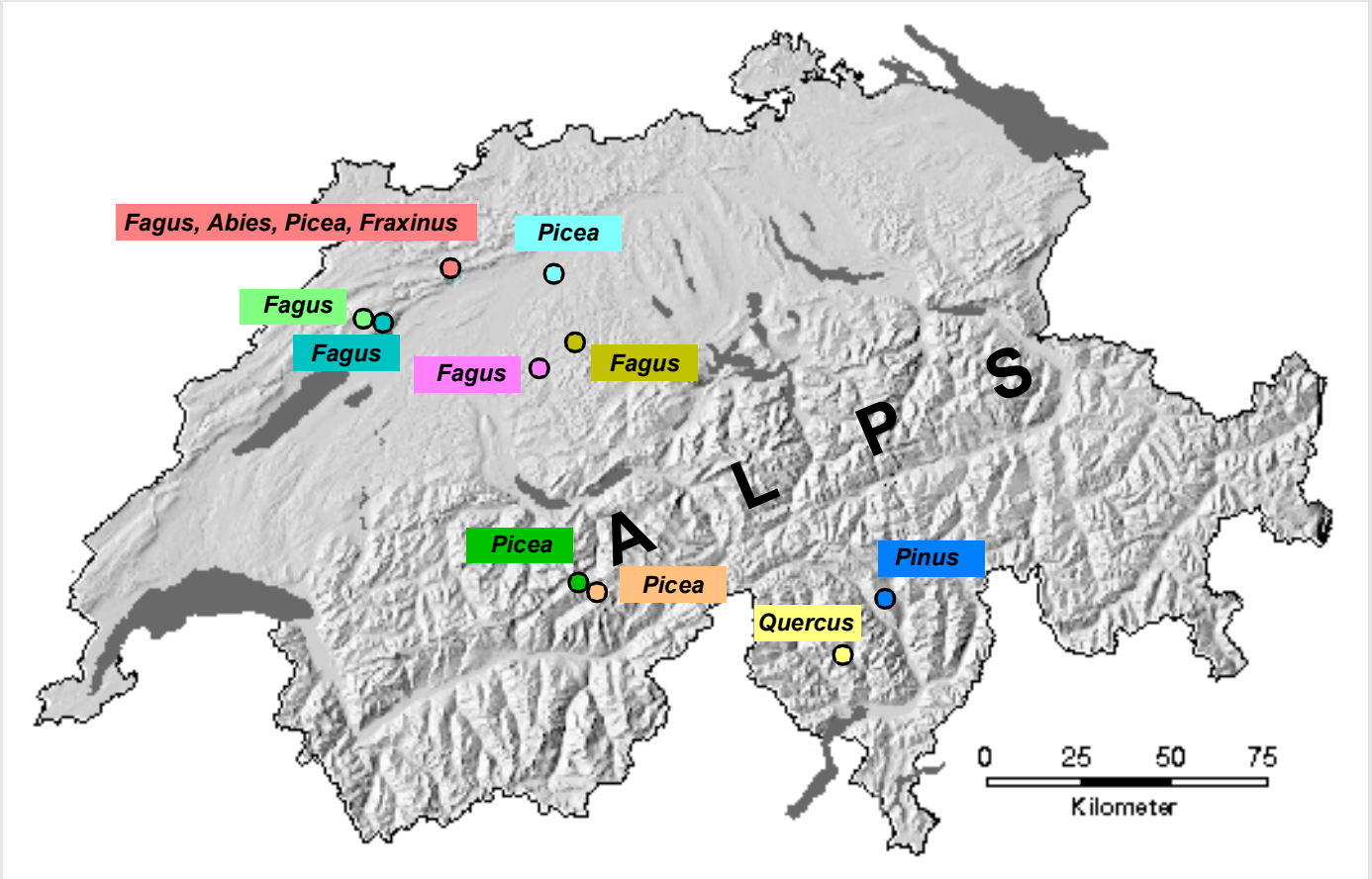
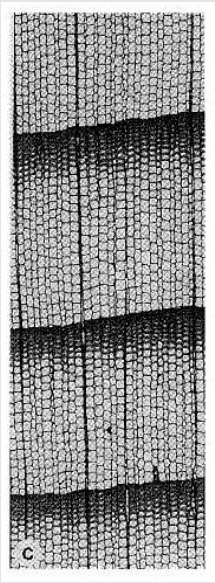
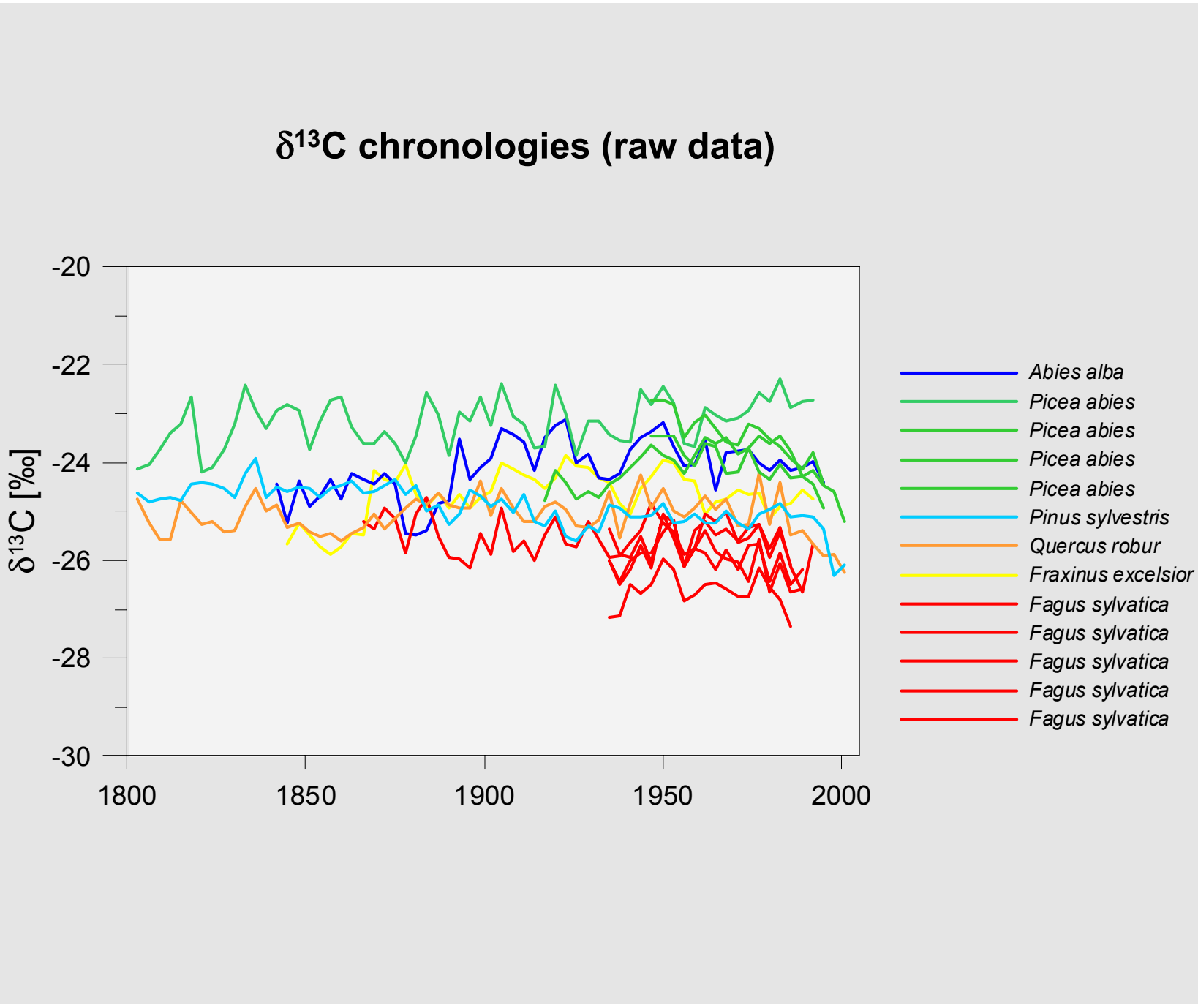


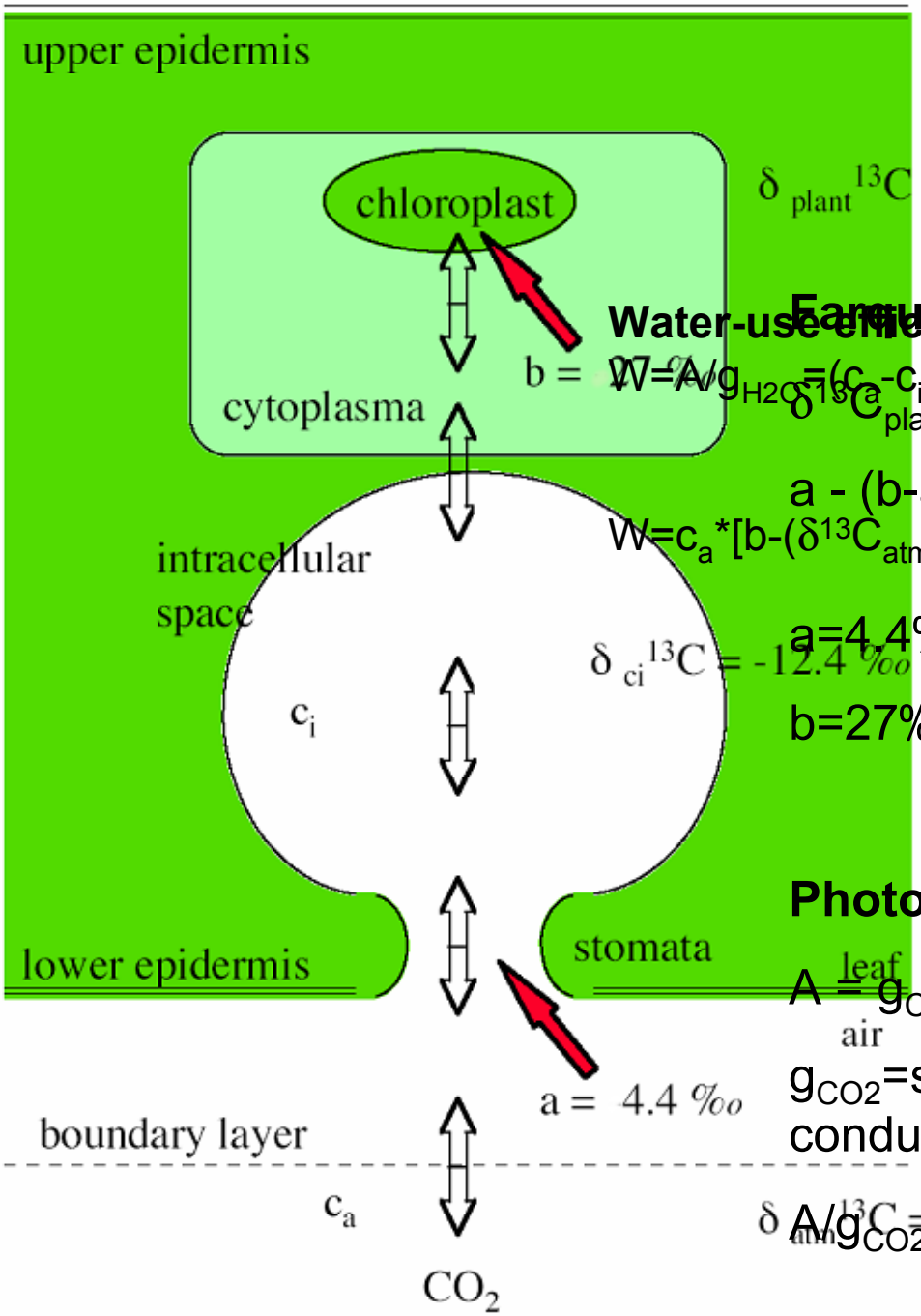
6 tree species, 13 chronologies, divers range of site conditions (dry/humid, altitude from 480m to 1900m a.s.l.)

Isotopes in tree-ring studies

element	isotope	abundance [%]
carbon	^{12}C	98.890
	^{13}C	1.110
nitrogen	^{14}N	99.630
	^{15}N	0.370
oxygen	^{16}O	99.759
	^{17}O	0.037
	^{18}O	0.204




δ13C chronologies (raw data)
δ13C [‰]
-20
-22
-24
-26
-28
-30
1800
1850
1900
1950
2000
Abies alba
Picea abies
Picea abies
Picea abies
Picea abies
Pinus sylvestris
Quercus robur
Fraxinus excelsior
Fagus sylvatica
Fagus sylvatica
Fagus sylvatica
Fagus sylvatica
Fagus sylvatica



Water-use efficiency

$W = A/g_{H2O}$

Farquhar-model:

$\Delta^{13}C_{plant} \approx \delta^{13}C_{atm} - a - (b-a)*c_i/c_a$

$W = c_a*[b-(\delta^{13}C_{atm}-\delta^{13}C_{plant})/(b-a)]/1.6$

a=4.4‰

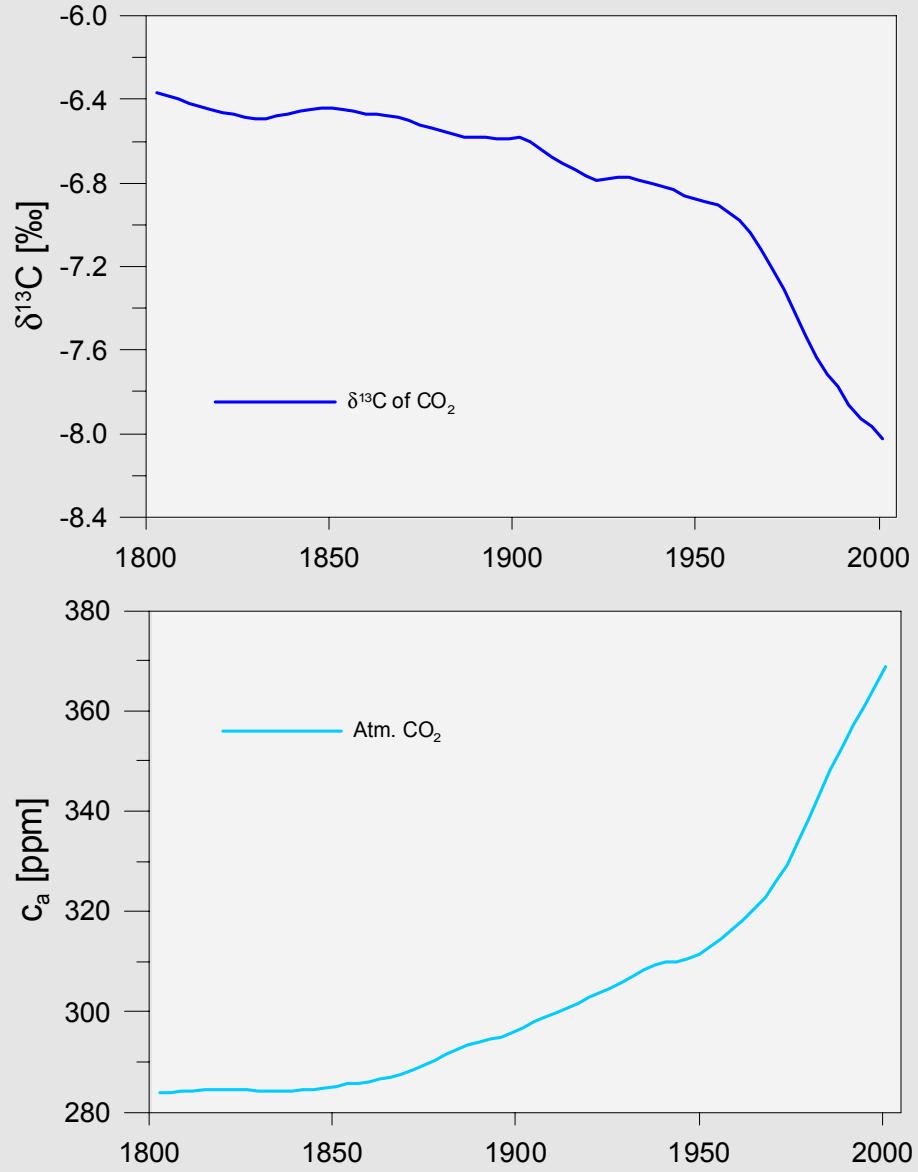
b=27‰

Photosynthesis A:

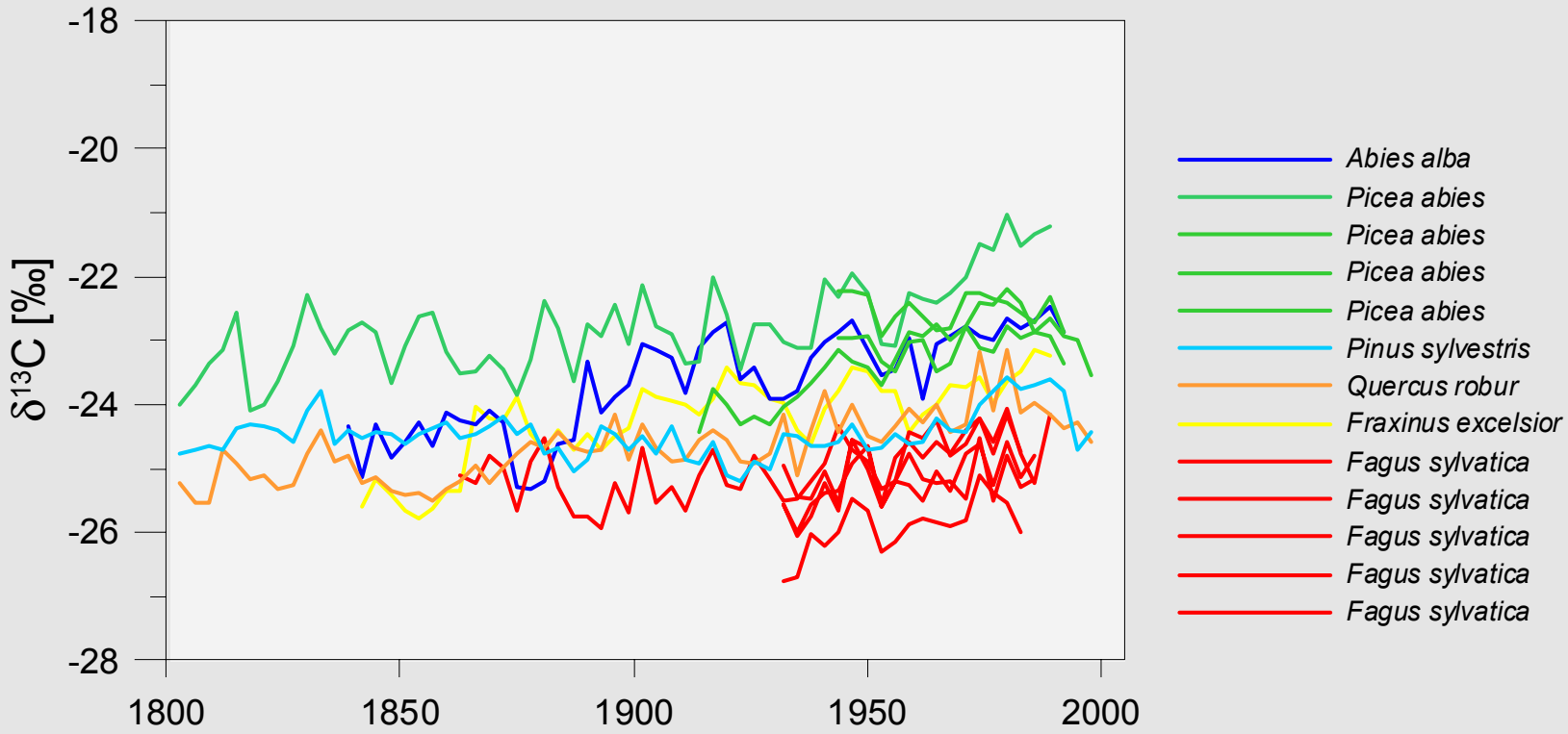
$A = g_{CO2}*(c_a-c_i)$

g_{CO2}=stomatal conductance

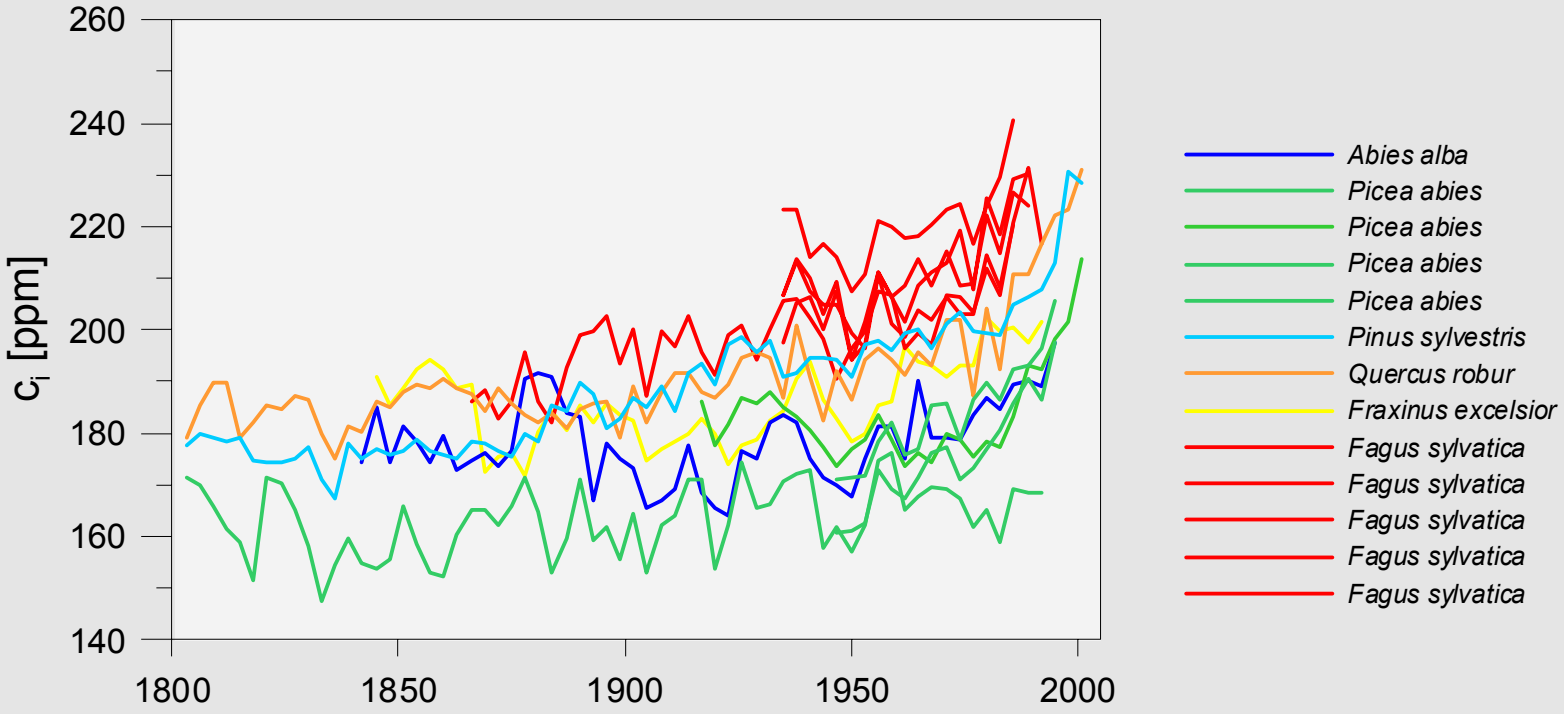
$A/g_{CO2} = (c_a-c_i)$


-6.0
-6.4
-6.8
-7.2
-7.6
-8.0
-8.4
δ13C [‰]
δ13C of CO2
1800
1850
1900
1950
2000
380
360
340
320
300
280
ca [ppm]
Atm. CO2
1800
1850
1900
1950
2000

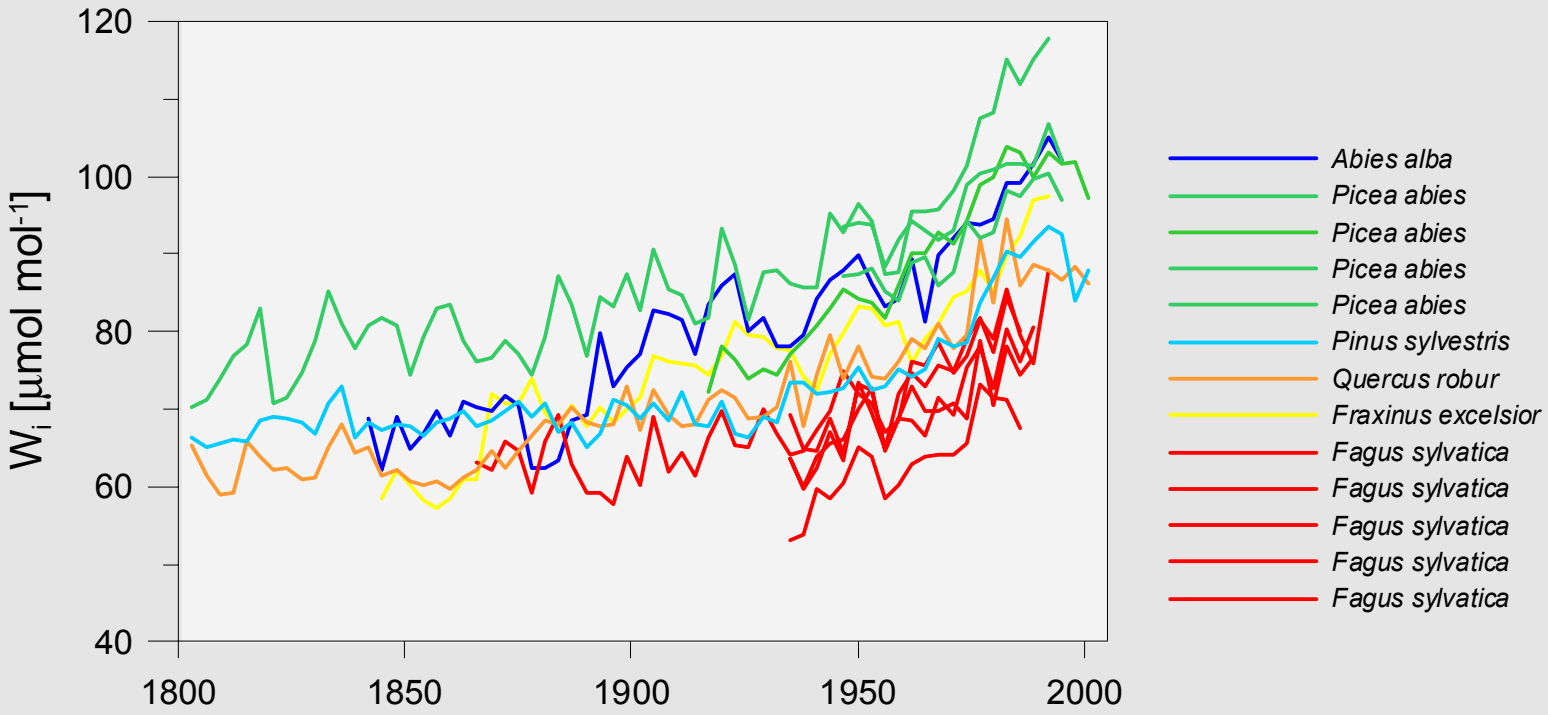
$\delta^{13}C$: time series after correction for atmospheric $\delta^{13}C$ change



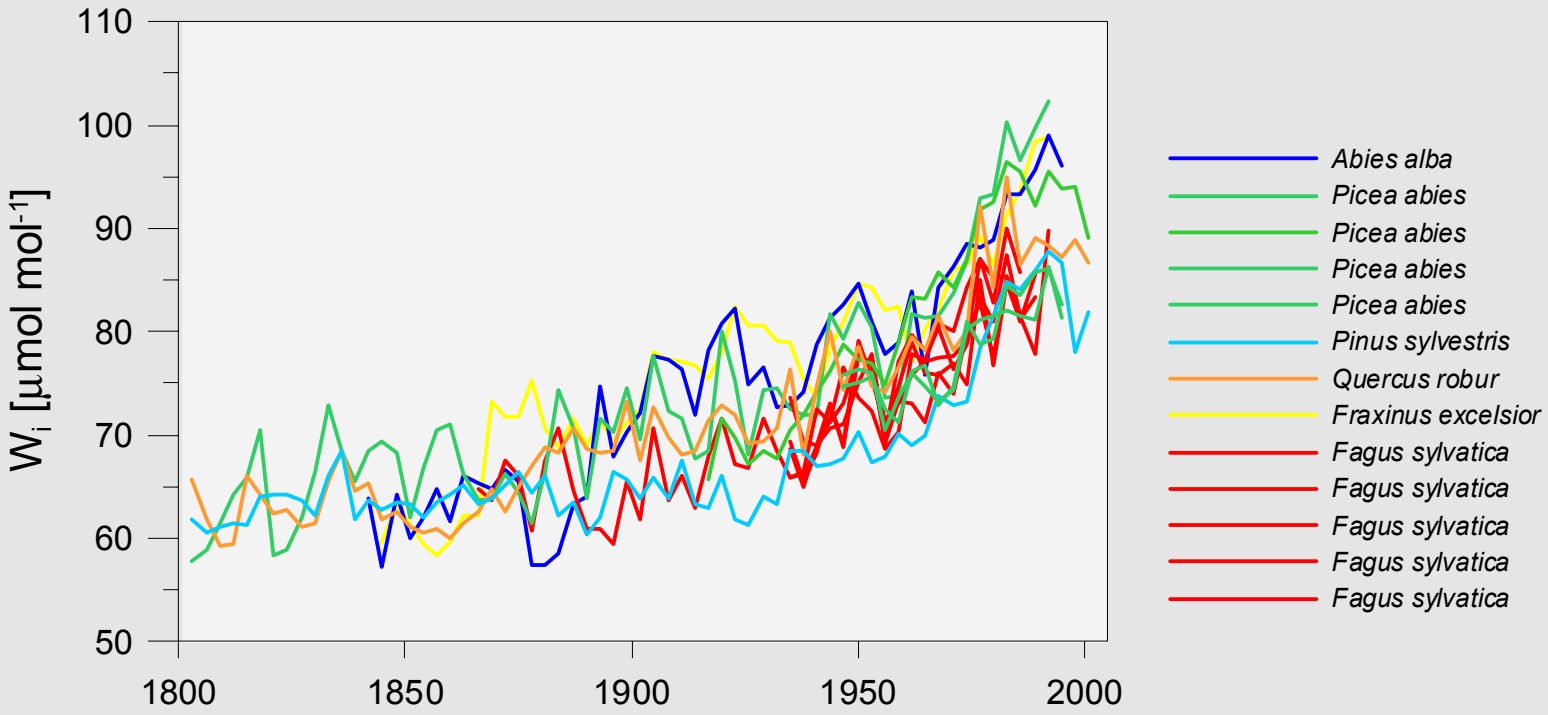
c_i: time series of the intercellular CO_2-concentration



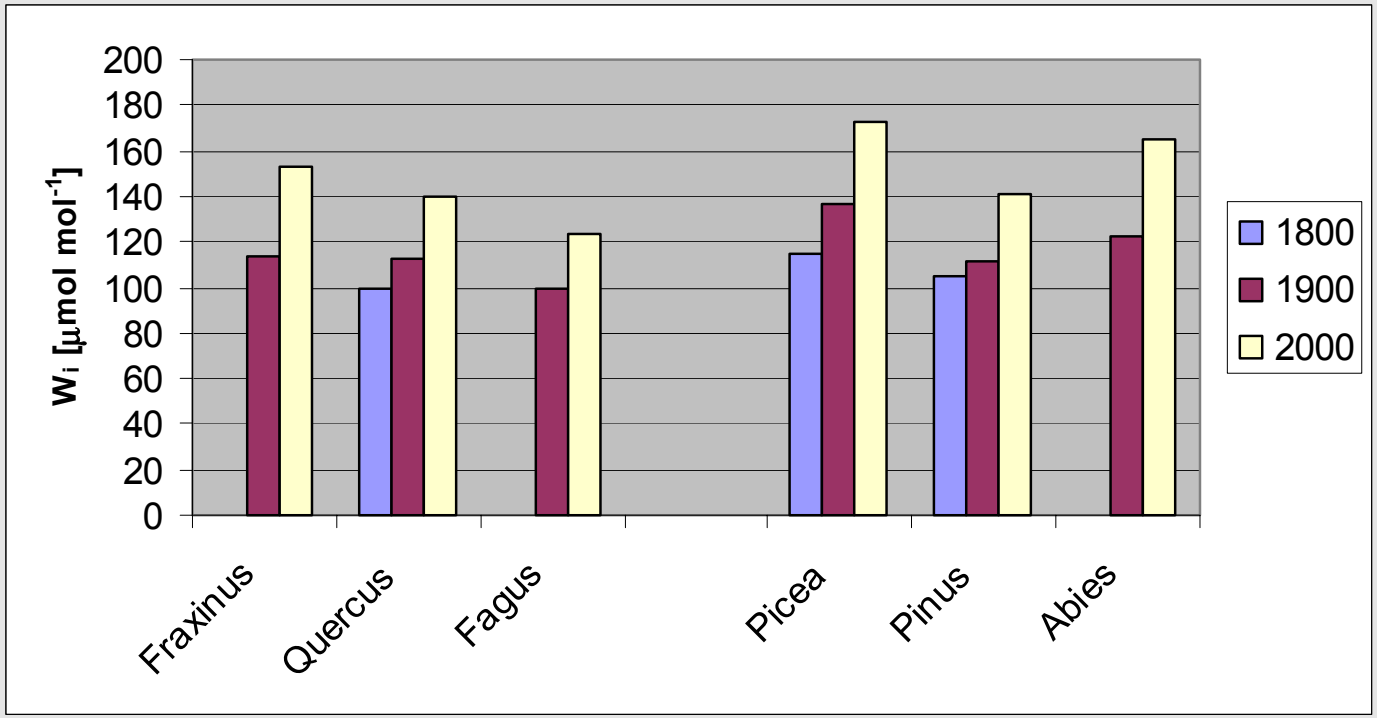
W_i: time series of the water-use efficiency



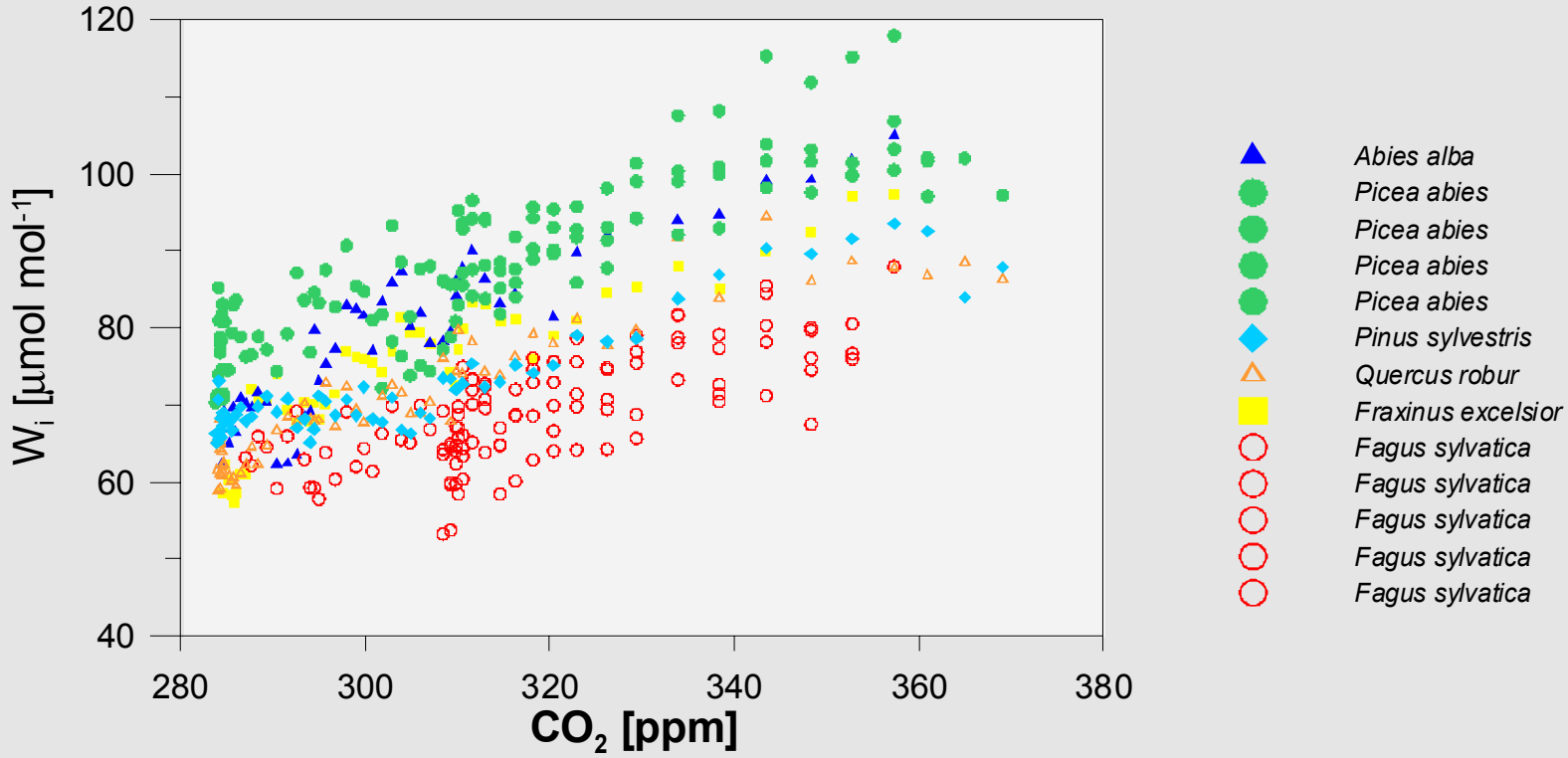
W_i: time series of the water-use efficiency, species-offset corrected



W_i: water-use efficiency, average values for the years 1800, 1900 and 2000



W_i: water-use efficiency, dependence on the atmospheric CO_2-concentration



Conclusions (1-4):

1) The water-use efficiency of trees in Switzerland increased dramatically in the last two centuries

2) The increase was independent of species, in the order of 35-50%

3) This indicates that trees are transpiring less water today with important implications on the water balance

4) More water-saturated soils with less capacity to absorb heavy rains and increased potential for flooding?

Thank you for your attention

More information on isotope work at PSI can be found at
isotope.web.psi.ch