Climate Signals in Tree-Ring Isotopes
(more than want to know)-
Mainly Carbon

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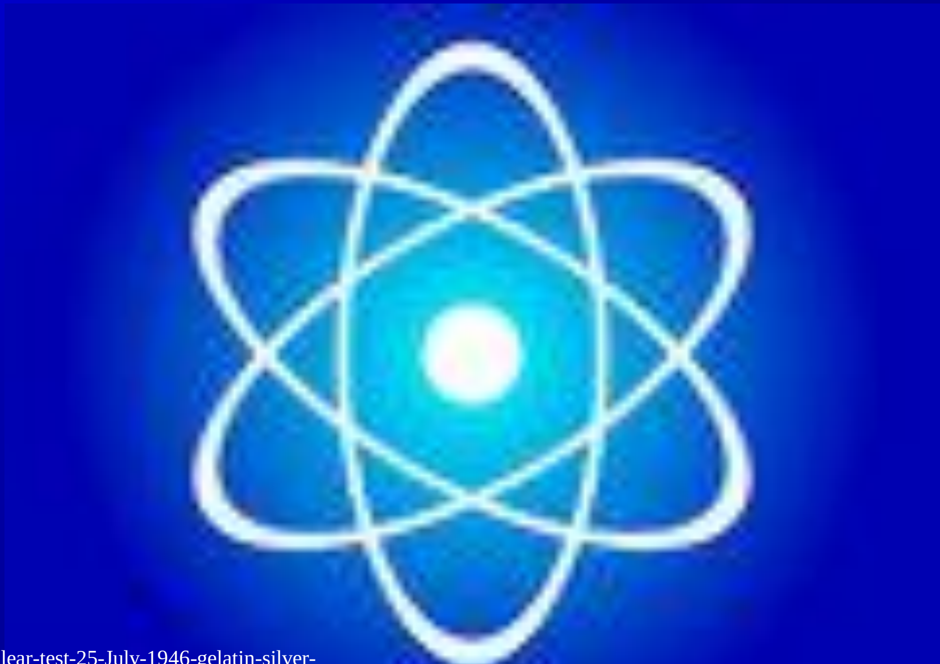


http://www.ltrr.arizona.edu/~sleavitt/IsoDendroBib.htm

http://www.bridgemanart.com/image/American-Photographer-20th-century/Mushroom-Cloud-Bikini-Atoll-nuclear-test-25-July-1946-gelatin-silver-print/2767d43f76c54193a496a302617ac10a?key=nuclear%20weapon&filter=CBPOIHV&thumb=x150&num=15&page=2

http://www.pixmac.com/picture/atomic+structure/000026544427

Isotopes at International Tree-Ring Meetings

1980- **2 Papers**
2nd International Workshop on Global Dendroclimatology, East Anglia, England

1990- **3 Papers**
International Dendrochronological Symposium, Ystad, South Sweden

2006- **30 Papers**
7th International Conference on Dendrochronology, Beijing, China

2010- **32 Papers**
WorldDendro, Rovaniemi, Finland
[19 oral presentations; 13 poster presentations]

2014- **36 Papers**
WorldDendro, Melbourne, Australia

Arctic, Antarctic, and Alpine Research, Vol. 41, No. 4, 2009, pp. 497–505

Climatic Signals in $\delta^{13}C$ and $\delta^{18}O$ of Tree-rings from White Spruce in the Mackenzie Delta Region, Northern Canada

*Trevor J. Porter**
Michael F. J. Pisaric§*
Steven V. Kokelj† and
Thomas W. D. Edwards‡

PNAS

Oxygen isotopes in tree rings are a good proxy for Amazon precipitation and El Niño-Southern Oscillation variability

Roel J. W. Brienen[a,b,1], Gerd Helle[c], Thijs L. Pons[d], Jean-Loup Guyot[e], and Manuel Gloor[a]

ELSEVIER
Available online at www.sciencedirect.com
ScienceDirect
Geochimica et Cosmochimica Acta 74 (2010) 2327–2339
Geochimica et Cosmochimica Acta
www.elsevier.com/locate/gca

Investigating the influence of sulphur dioxide (SO_2) on the stable isotope ratios ($\delta^{13}C$ and $\delta^{18}O$) of tree rings

Switsur [a], K.S. Treydte [c], J.S. Waterhouse [a]

Plant, Cell and Environment (2003) **26**, 631–644

Carbon isotope discrimination and growth response of old *Pinus ponderosa* trees to stand density reductions

N. McDOWELL[1], J. R. BROOKS[2], S. A. FITZGERALD[3] & B. J. BOND[1]

Global Change Biology (2010), doi: 10.1111/j.1365-2486.2010.02273.x

Evidence of changing intrinsic water-use efficiency under rising atmospheric CO_2 concentrations in Boreal Fennoscandia from subfossil leaves and tree ring $\delta^{13}C$ ratios

MARY GAGEN*, WALTER FINSINGER†‡, FRIEDERIKE WAGNER-CREMER†, DANNY MCCARROLL*, NEIL J. LOADER*, IAIN ROBERTSON*, RISTO JALKANEN§, GILES YOUNG* and ANDREAS KIRCHHEFER¶

http://www.ltrr.arizona.edu/~sleavitt/IsoDendroBib.htm

Progress and challenges in using stable isotopes to trace plant carbon and water relations across scales

Biogeosciences, 9, 3083–3111, 2012
www.biogeosciences.net/9/3083/2012/
doi:10.5194/bg-9-3083-2012

C. Werner[1,19], H. Schnyder[2], M. Cuntz[3], C. Keitel[4], M. J. Zeeman[5], T. E. Dawson[6], F.-W. Badeck[7], E. Brugnoli[8], J. Ghashghaie[9], T. E. E. Grams[10], Z. E. Kayler[11], M. Lakatos[12], X. Lee[13], C. Máguas[14], J. Ogée[15], K. G. Rascher[1], R. T. W. Siegwolf[16], S. Unger[1], J. Welker[17], L. Wingate[18], and A. Gessler[11]

Biogeosciences

Quaternary Science Reviews 165 (2017) 102–110

Quaternary Science Reviews

Seasonal variability in Northern Hemisphere atmospheric circulation during the Medieval Climate Anomaly and the Little Ice Age

Thomas W.D. Edwards [a,*], Dan Hammarlund [b], Brandi W. Newton [c], Jesper Sjolte [b], Hans Linderson [b], Christophe Sturm [d], Natalie A. St. Amour [a], Joscelyn N.-L. Bailey [a], Anders L. Nilsson [b]

Functional Ecology 2017

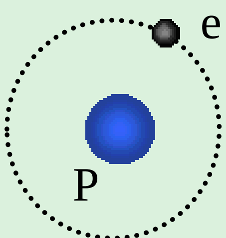
doi: 10.1111/1365-2435.12889

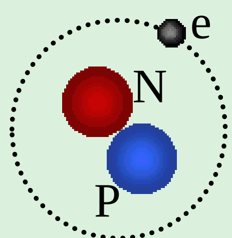
Stable isotopes in tropical tree rings: theory, methods and applications

Peter van der Sleen[1,2], Pieter A. Zuidema[1] and Thijs L. Pons[*,3]

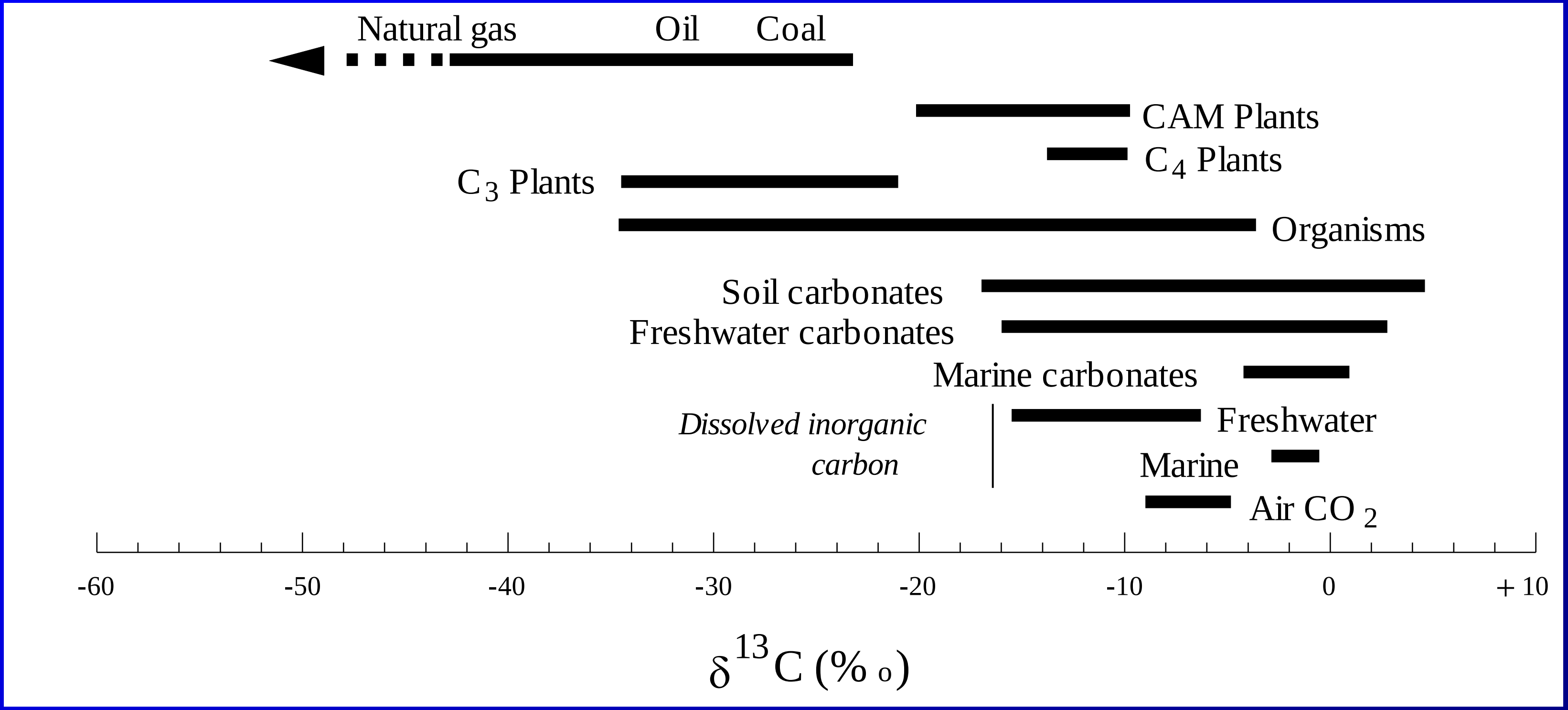
WHAT ARE ISOTOPES?

Element	Isotope	Abundance (%)
Hydrogen	^{1}H	99.985
	^{2}H	0.015
Carbon	^{12}C	98.89
	^{13}C	1.11
Radioactive →	^{14}C	$<10^{-10}$
Nitrogen	^{14}N	99.63
	^{15}N	0.37
Oxygen	^{16}O	99.759
	^{17}O	0.037
	^{18}O	0.204





Carbon Isotope Variability in Nature



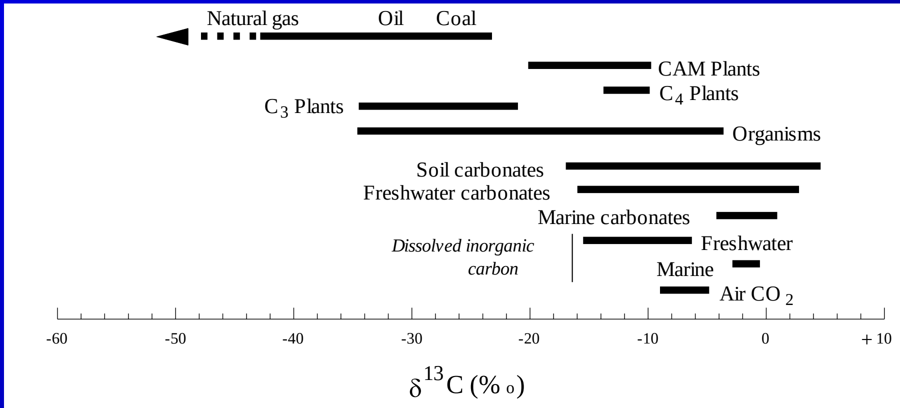
Leavitt, S.W., 2009. Carbon isotopes- stable. IN *Encyclopedia of Paleoclimatology and Ancient Environments*. Springer

In nature, isotopic “**fractionation**” causes differences in isotopic composition

Processes such as

- **equilibrium reactions**
- **change of state**
- **diffusion**

contribute to fractionation.



Fractionation during these processes is driven by differences in **mass** of the isotopes; **fractionation contributes to variability in isotope ratios among compounds**.

Consideration	Importance	Reason	How to accomplish
site selection	high	optimizes the strength of the environmental/ecophysiologic signal	select locations where the parameter of interest is particularly dominant
avoidance of pollution (if pollution is not the environmental parameter being investigated)	high	Pollution may negatively or positively bias metabolic performance of plants, including physiology related to isotope fractionation, e.g., stomatal conductance	sites can be located distant from point sources of pollution and cities; sometimes air quality data may be available to better insure avoidance of this affect
avoidance of other anthropogenic effects	high	human disturbance, e.g., forest clearing and grazing, may influence growth and physiology related to isotope fractionation	sites with known disturbance should be avoided
dendrochronological dating	high	ensures exact dates of isotope values compared within and between trees	species/location for which dating is likely
number of trees at each site	high	ensures isotopic value is representative of site	analyze isotopes of 3-6 trees/site; number should be proved using EPS (McCarroll and Loader 2004) and inter-series correlation
tree species	potentially high	using a single species could avoid physiological differences that affect isotopes among species	select single widespread species and use for climate calibration and reconstruction
environmental/ecophysiologic parameter of interest	high	project questions are related to a specific parameter	select species and location where the parameter of interest is particularly dominant
"juvenile" or age-related effects	high (at least for carbon and hydrogen)	early period of growth may be different than when the tree is mature, so isotopic composition in early rings may be anomalously more or less depleted because of non-climatic effects on fractionation; also general "age effects" might result from changing physiology as tree ages	careful trend analyses to identify the length of the juvenile period; potentially statistical de-trending; isotope values from innermost rings might be skipped; rings of similar cambial age might be analyzed and compared to avoid general "age effects" (e.g., Marshall and Monserud 2006)
portion of ring to be analyzed	potentially high	storage effects may result in significant time lag between photosynthesis and when the isotopic composition is incorporated into rings. therefore besides the more typical analysis of whole rings, other options might be preferred such as only earlywood, only latewood, or perhaps even latewood of one year+earlywood from the next	separate rings according to scheme that works best for project goals
pooling then analysis and isotope chronology development or separate development of chronologies from each tree and then averaging	high	can save time and resources if rings from several trees are pooled prior to analysis, but statistical assessment of reconstructions is less certain if pooled.	will probably depend on project goals, but at least some separate analysis of trees needed to quantitatively assess inter-tree variability
chemical pretreatment	uncertain	ensures confidence that isotopic value represents the year of interests	cellulose has long been advocated, but in recent years whole wood or whole wood with extractives removed by organic solvents have been advocated as producing effectively equivalent results, at least for $\delta^{13}C$; with sub-fossil wood, however, cellulose may not be an option

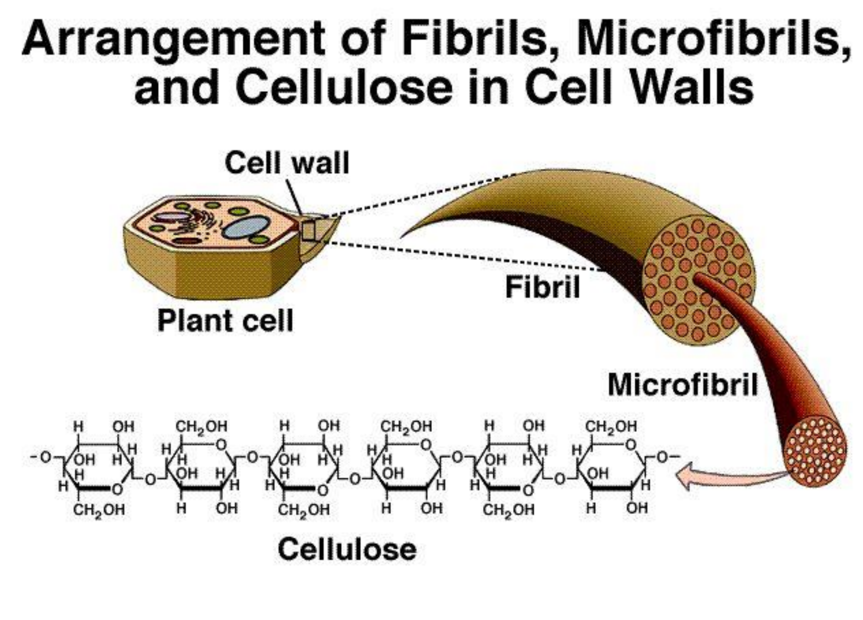
from Leavitt, S.W., Treydte, K., Yu, L., 2010. Environment in time and space: Opportunities from tree-ring isotope networks. IN *Understanding Movement, Pattern, and Processes on Earth Through Isotope Mapping*, Ch. 6. Springer.

CHEMICAL PRETREATMENT

What compounds in tree rings are available to us for measuring isotope ratios?

Table 3 Chemical Constituents of Wood

	% Composition	Polymeric nature	Degree of polymerization	Molecular building blocks	Role
Cellulose	45–50	linear molecule crystalline	5,000 –10,000	glucose	framework
Hemicellulose	20-25	branched molecule amorphous	150-200	primarily nonglucose sugars	matrix
Lignin	20-30	three-dimensional molecule	100-1,000	phenolpropane	matrix
Extractives	0-10	polymeric	—	polyphenols	encrusting

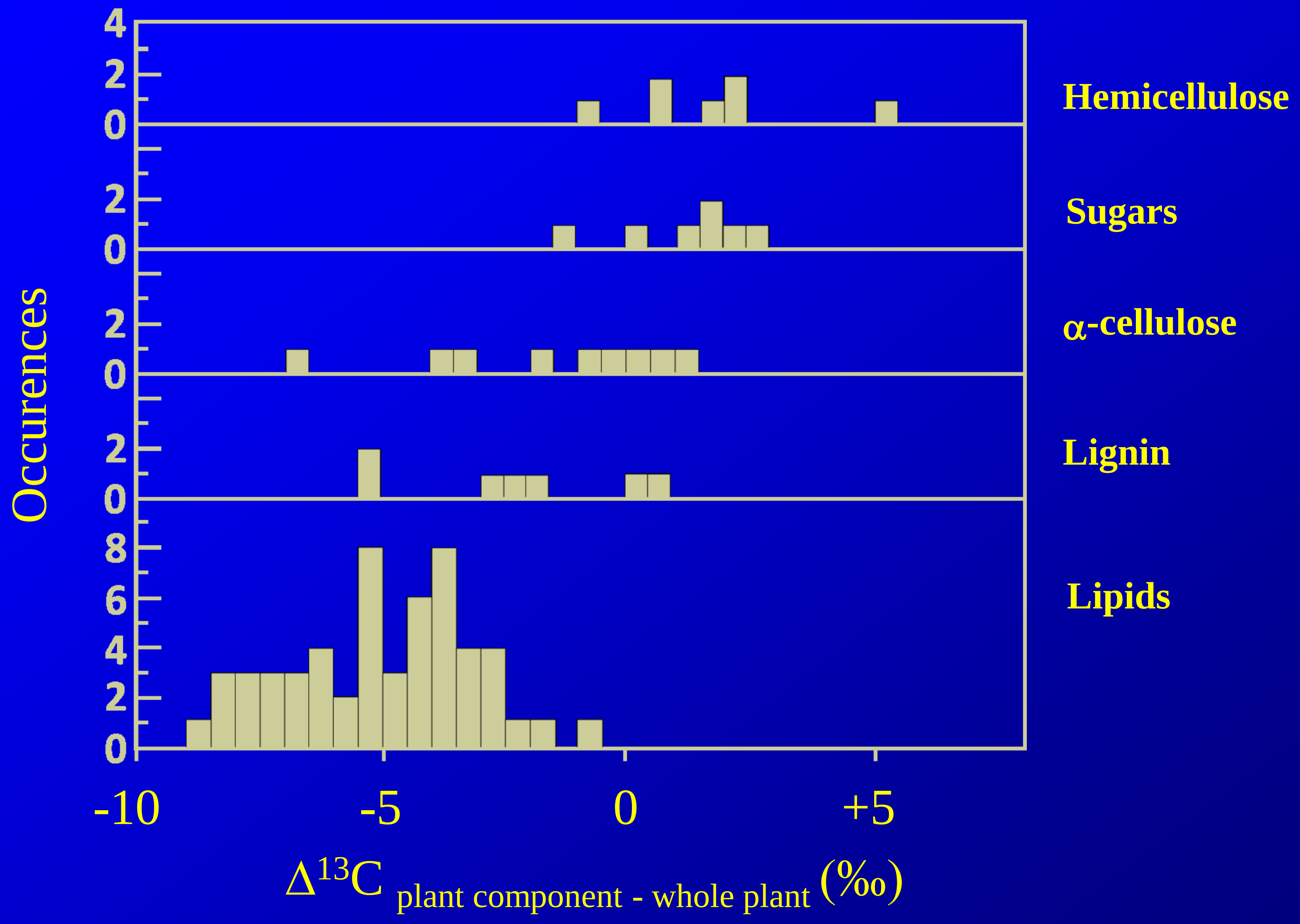


(Panshin& Zeeuw 1980)

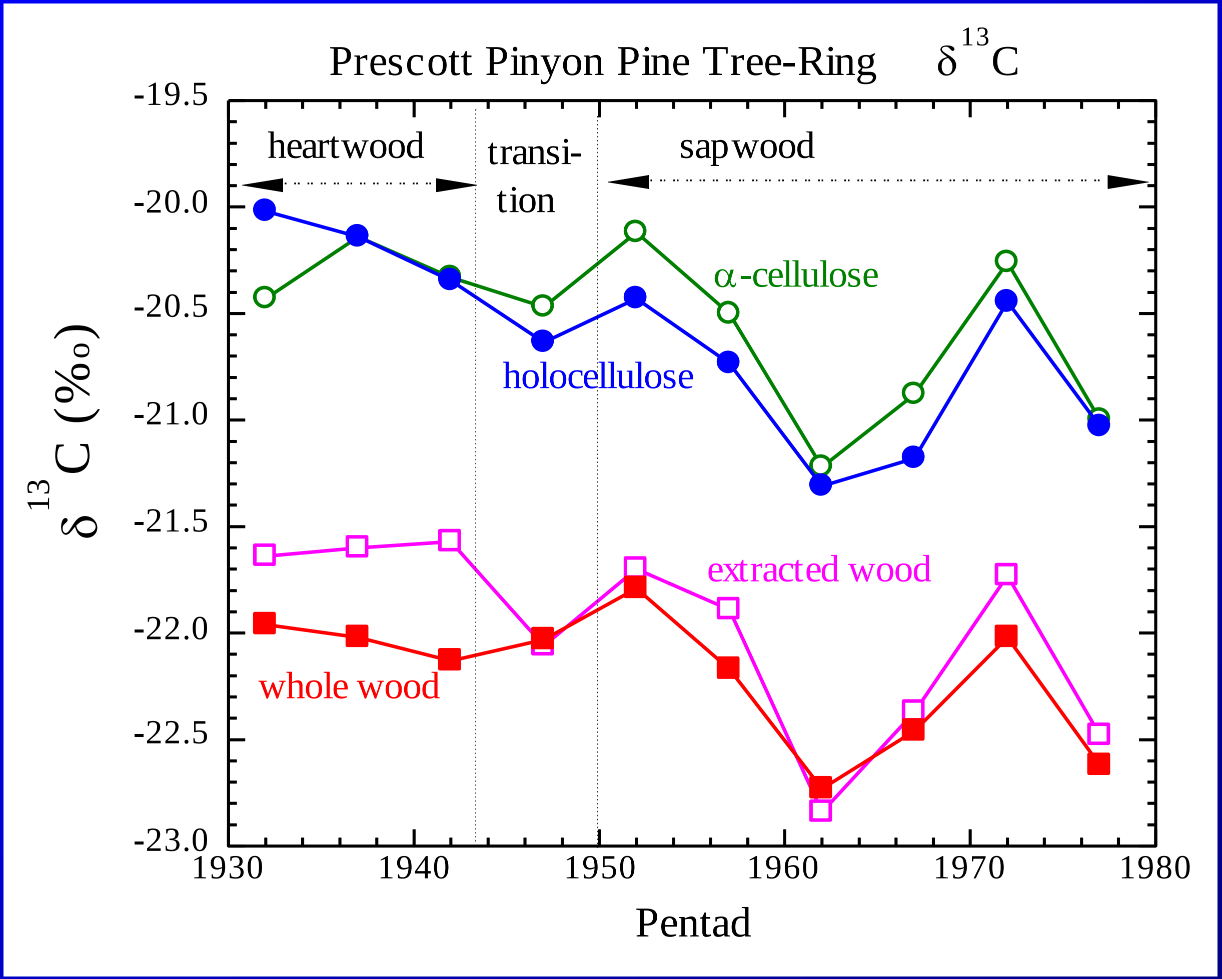
Plant components, approximate % dry weight and relative tissue decomposition rate

Plant component	% dry weight	General Composition	Relative Decomposition*
Carbohydrates		CHO	
Sugars, Starches	1-5		1
Hemicelluloses	10-30		4
Cellulose	20-50		5
Proteins		CHONPS	
simple H_2O-soluble			2
conjugated			3
Lignins	10-30	CHO	6
Lipids	1-8	CHO	7

* 1-7, Highest to Lowest

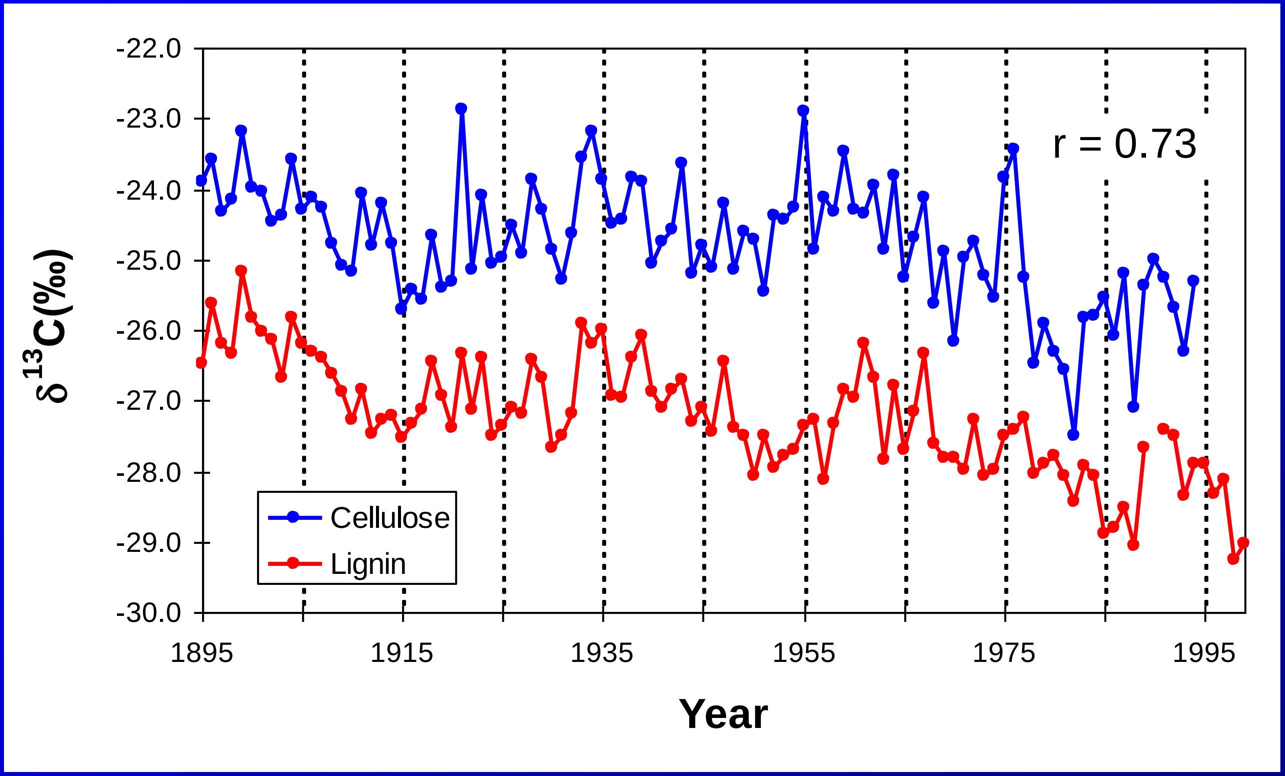


Deines, P. In: Fritz & Fontes. 1980. Handbook of Environmental Isotope Geochemistry V.1. The Terrestrial Environment.



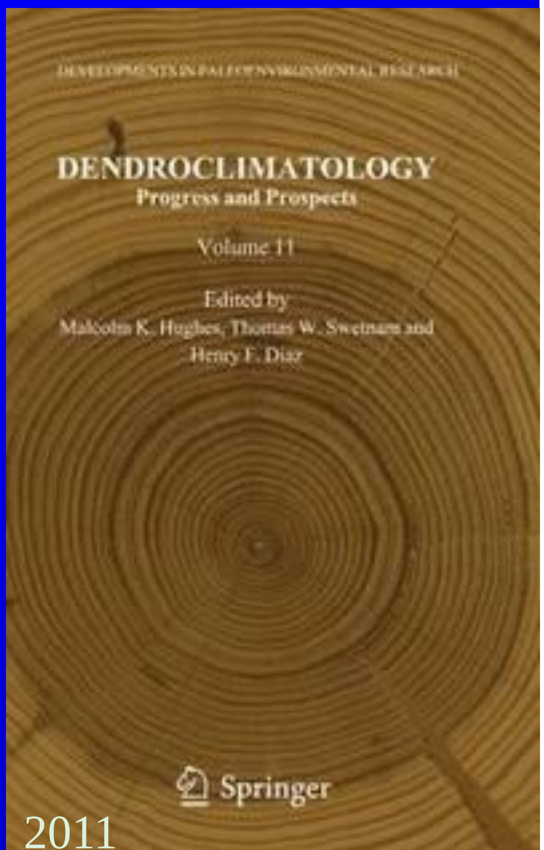
Leavitt 1987

Oak (England) α-cellulose and lignin



(Robertson et al., 2004)

NUMBER OF TREES TO SAMPLE



2011

Chapter 6
Stable Isotopes in Dendroclimatology: Moving Beyond 'Potential'

Mary Gagen, Danny McCarroll, Neil J. Loader, and Iain Robertson

Abstract When trees grow, they assimilate carbon from atmospheric carbon dioxide, and hydrogen and oxygen from soil water. The stable isotope ratios of these three elements carry signals that can be interpreted in terms of past climate because isotope ratios are climatically controlled by the tree's water and gas exchange budgets. The traditional tree-ring proxies form the most widespread and arguably the most valuable of the high-resolution climate archives. Here we asses the added contribution that can be made to dendroclimatology using stable isotope measurements. We describe what is involved in measuring tree-ring stable isotopes, provide a brief review of progress to date, and point to the ways in which stable isotope dendroclimatology can be used to provide something new. We conclude that stable isotope ratios sometimes provide stronger climate signals than the traditional proxies, which can be useful where sample replication is limited. Stable isotopes can also be used

How "well-behaved" is stable-isotope composition in tree rings? (i.e., how variable is it?)

http://www.danheller.com/images/California/Humboldt/Redwoods/Slideshow/img7.html

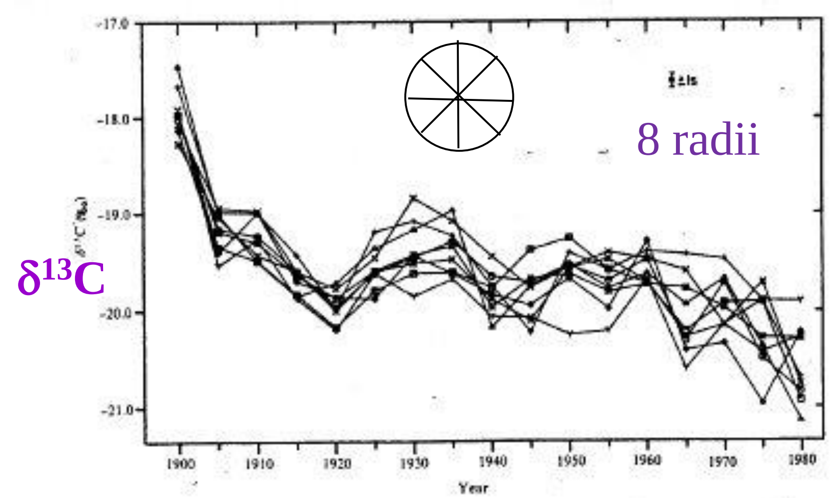
Circumferential

[Variability among radii]

$\delta^{18}O$

$\delta^{2}H$

$\delta^{13}C$



$\delta^{13}C$

Fig. 1 The $\delta^{13}C$ trends of 5-yr ring groups (values plotted at the beginning of each 5-yr interval) from eight radii of a *P. edulis* tree sampled south of Flagstaff, Arizona. •, The $\delta^{13}C$ trend from an adjacent cross-section whose ring-groups were collected from the full circumference.

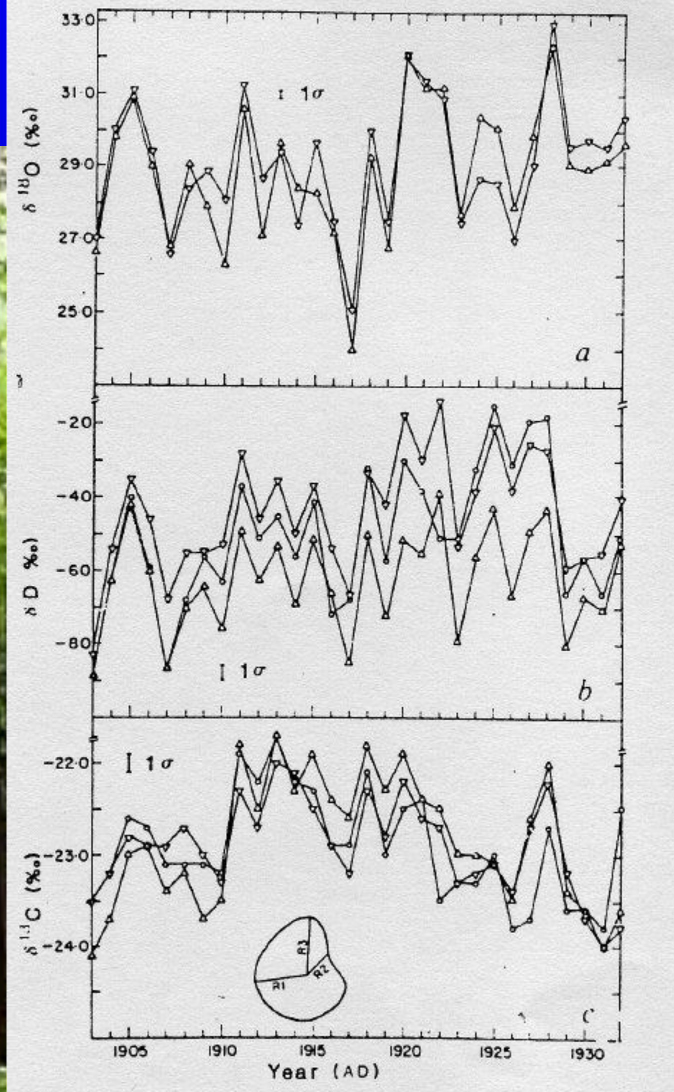


Fig. 1 *a*, $\delta^{18}O$ values of cellulose from individual rings along two radii R1 and R2 of tree AP2 (*Abies pindrow*). *b*, δD values and *c*, $\delta^{13}C$ values of nitrated cellulose from rings along three radii, R1, R2 and R3, of the same tree. △, Samples along R1; ▽, samples along R2; ○, samples along R3. Experimental uncertainty is given as 1σ (s.d.).

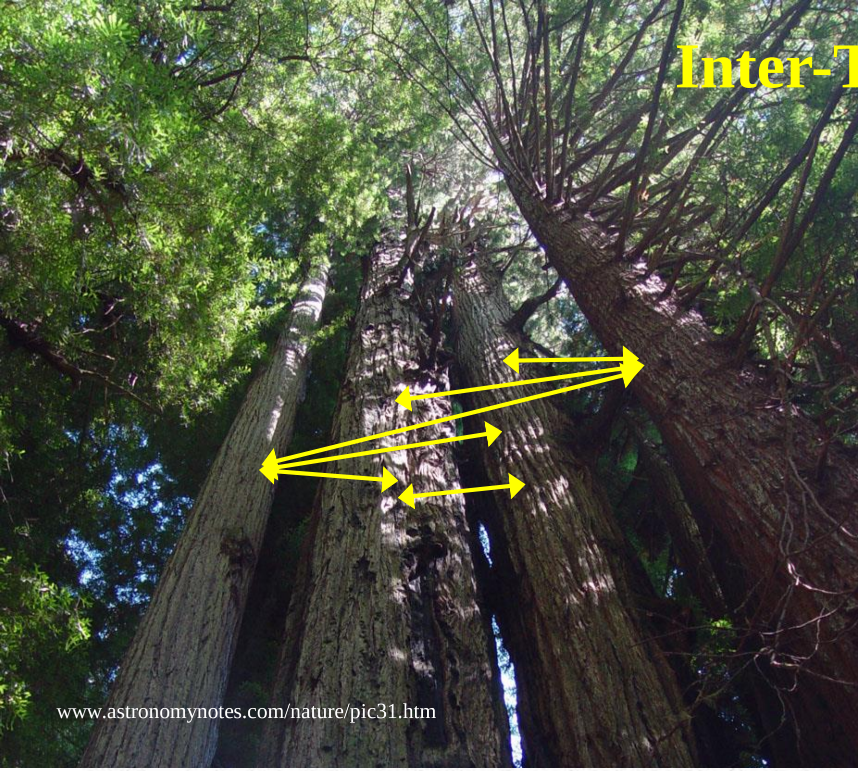
(From Ramesh et al., 1985. Nature 317:802-804)

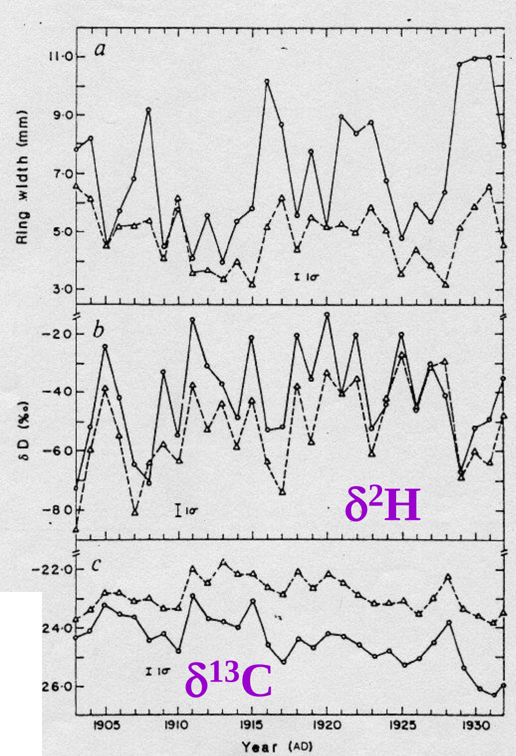
(Leavitt & Long 1984)

Inter-Tree

2 *Abies pindrow* trees

2 *Abies pindrow* trees,
1 *Cedrus deodara*,
1 *Pinus wallichiana*





. 2 a, Ring width, b, δD and c, δ^{13}C values of individual rings
n AP2 and AP3 (*A. pindrow*). Ring widths for both trees are
rage values of measurements along different radial directions.
and δ^{13}C of nitrated cellulose are means of three radial
asurements in the case of AP2. ○, Samples from AP3; △, samples
from AP2.

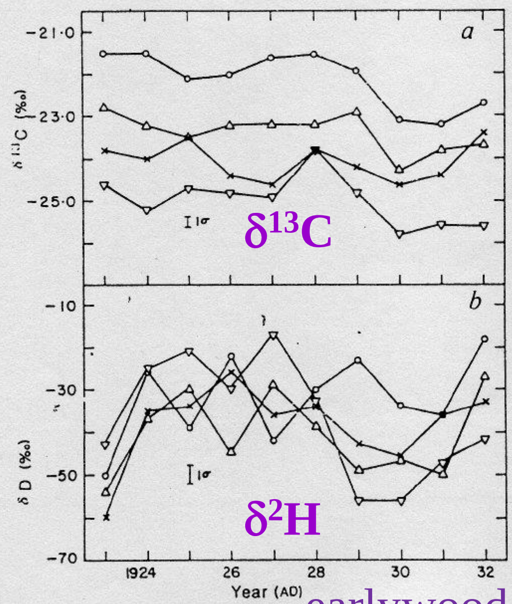
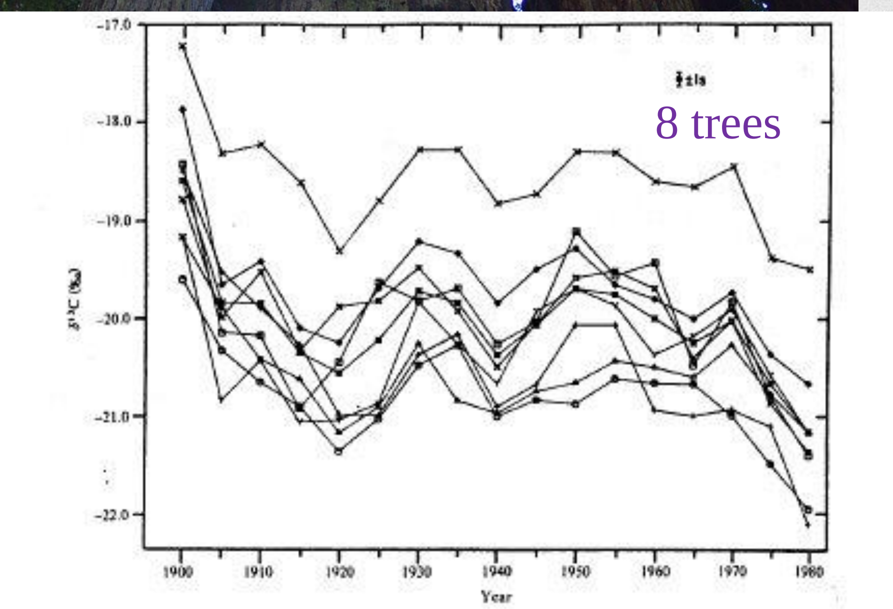


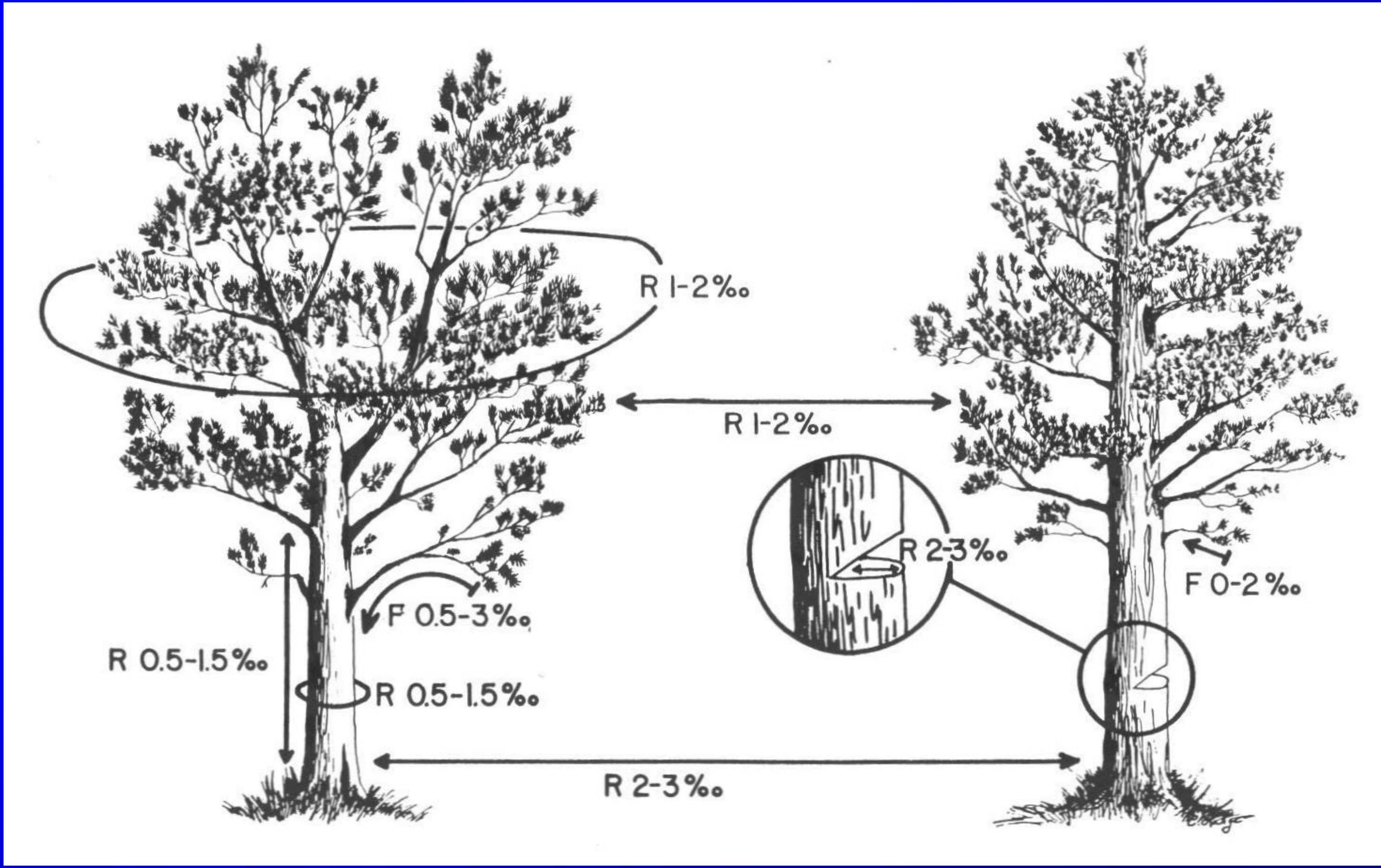
Fig. 3 a, δ^{13}C and b, δD values of nitrated cellulose from early wood part of individual rings from four trees. ○, Samples from CD1 (*Cedrus deodara*); △, samples from AP2 (*Abies pindrow*); ×, samples from PW3 (*Pinus wallichiana*); ▽, samples from AP3 (*Abies pindrow*).



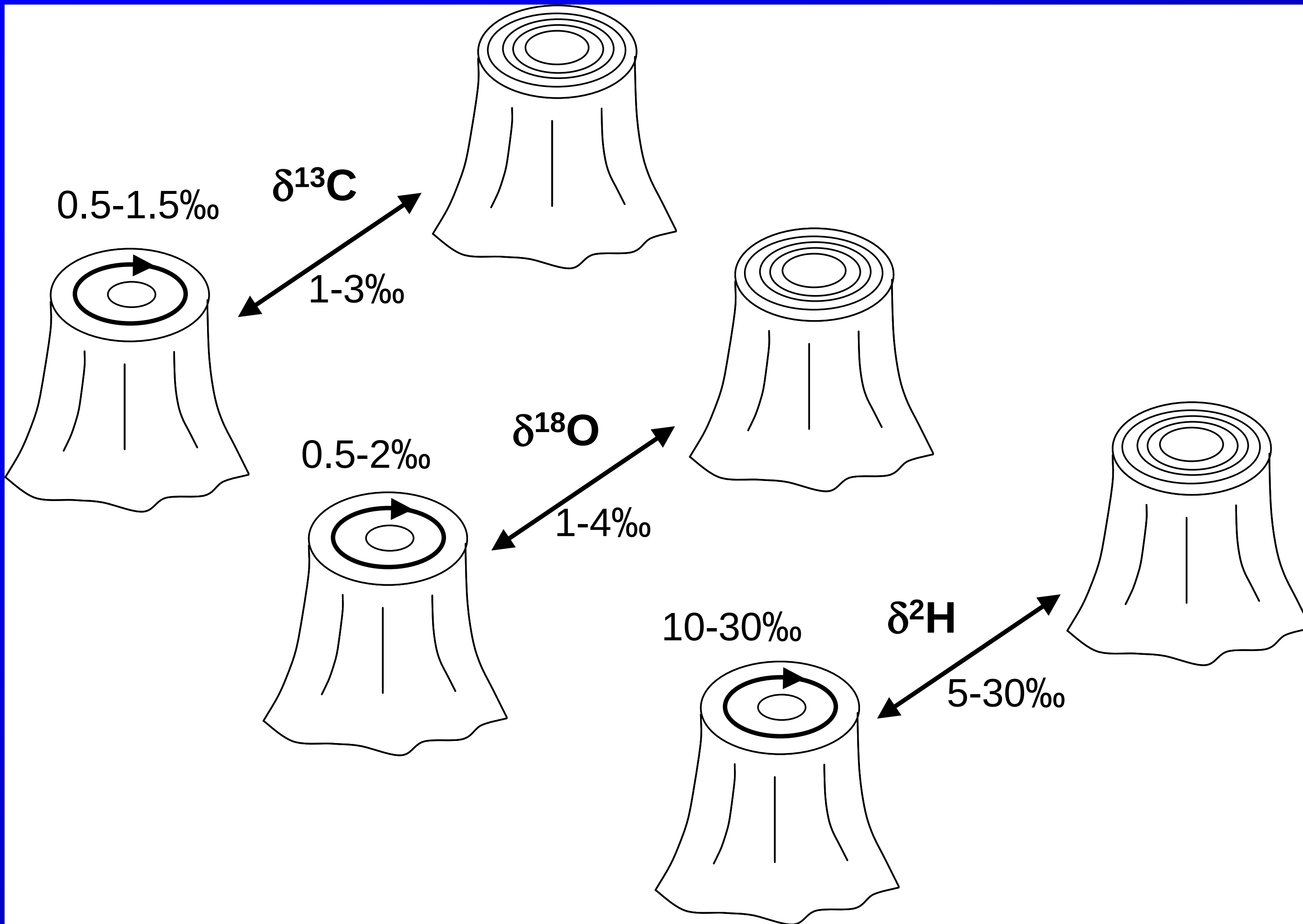
(Leavitt & Long 1984)

(From Ramesh et al., 1985. Nature 317:802-804)

Inter and Intra tree variation in $\delta^{13}C$ in pinyon pine, Arizona



(Leavitt & Long, 1986. Ecology 67: 1002-1010)



Leavitt 2010

So………

what contributes to the isotopic composition we measure in tree rings?

MODELS OF TREE-RING ISOTOPES

First, the source of isotopes………

$H_2O + CO_2 \rightarrow CH_2O + O_2$ (photosynthesis)

Carbon comes from CO_2

How do the hydrogen and oxygen isotopes of water get incorporated into cellulose?

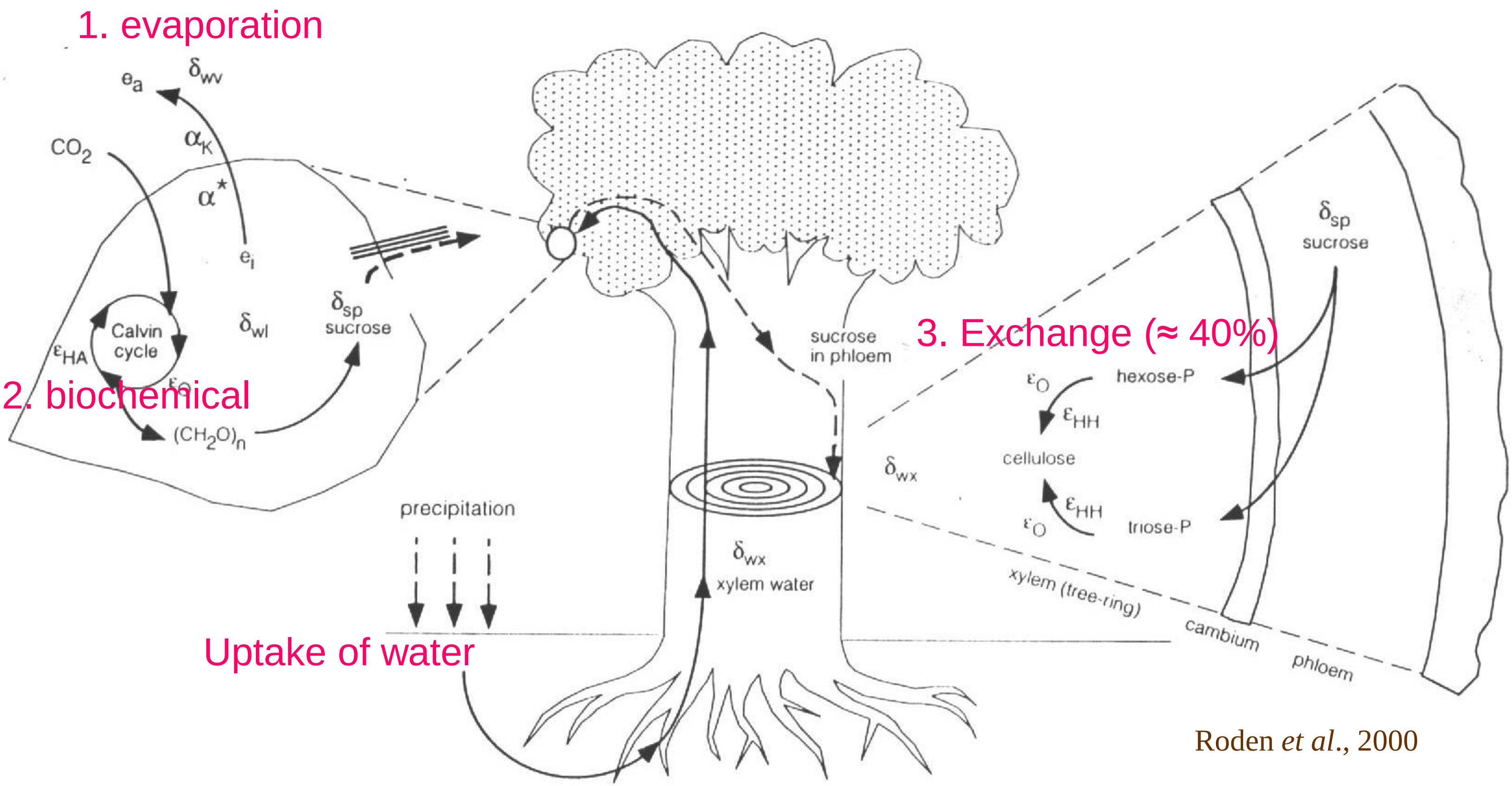
All the H in organic matter comes from water.
(most from **water taken up by roots**, but some also from atmospheric vapor)

Oxygen could come from either CO_2 or water, but when CO_2 goes into solution it quickly exchanges its O with the much more abundant water, so again **water taken up by roots** dominates. (DeNiro and Epstein, 1979)

Processes key to
Hydrogen ($^{2}H/^{1}H$) and Oxygen ($^{18}O/^{16}O$) isotopes in tree rings

- **Local "source" water for plants (precipitation/soil/groundwater)**
- **Evaporation**
- **Biochemical Fractionation (autotrophic and heterotrophic)**
- **Isotopic Exchange**

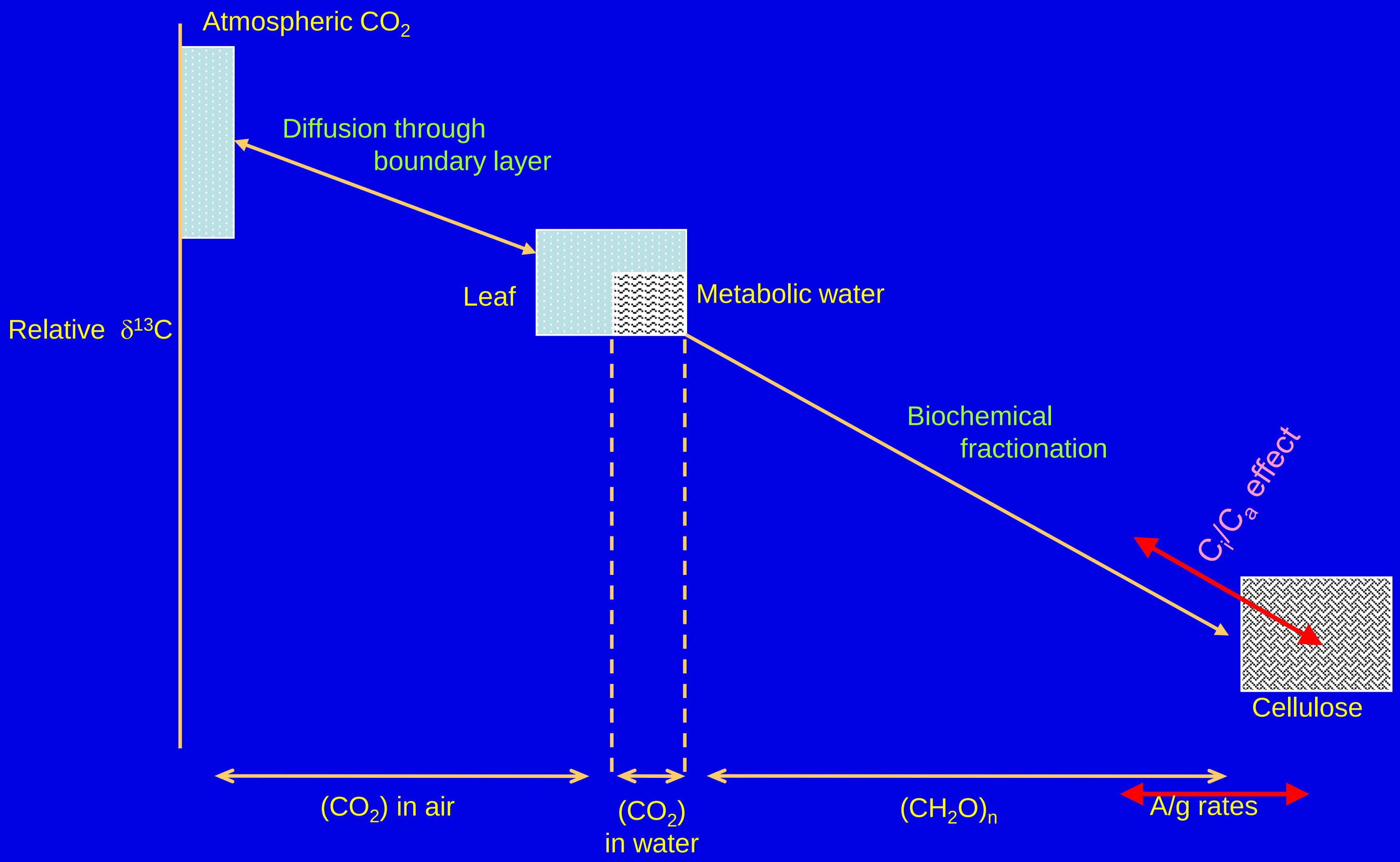
Schematic of $\delta^{18}O$ and δD model



Roden *et al.*, 2000

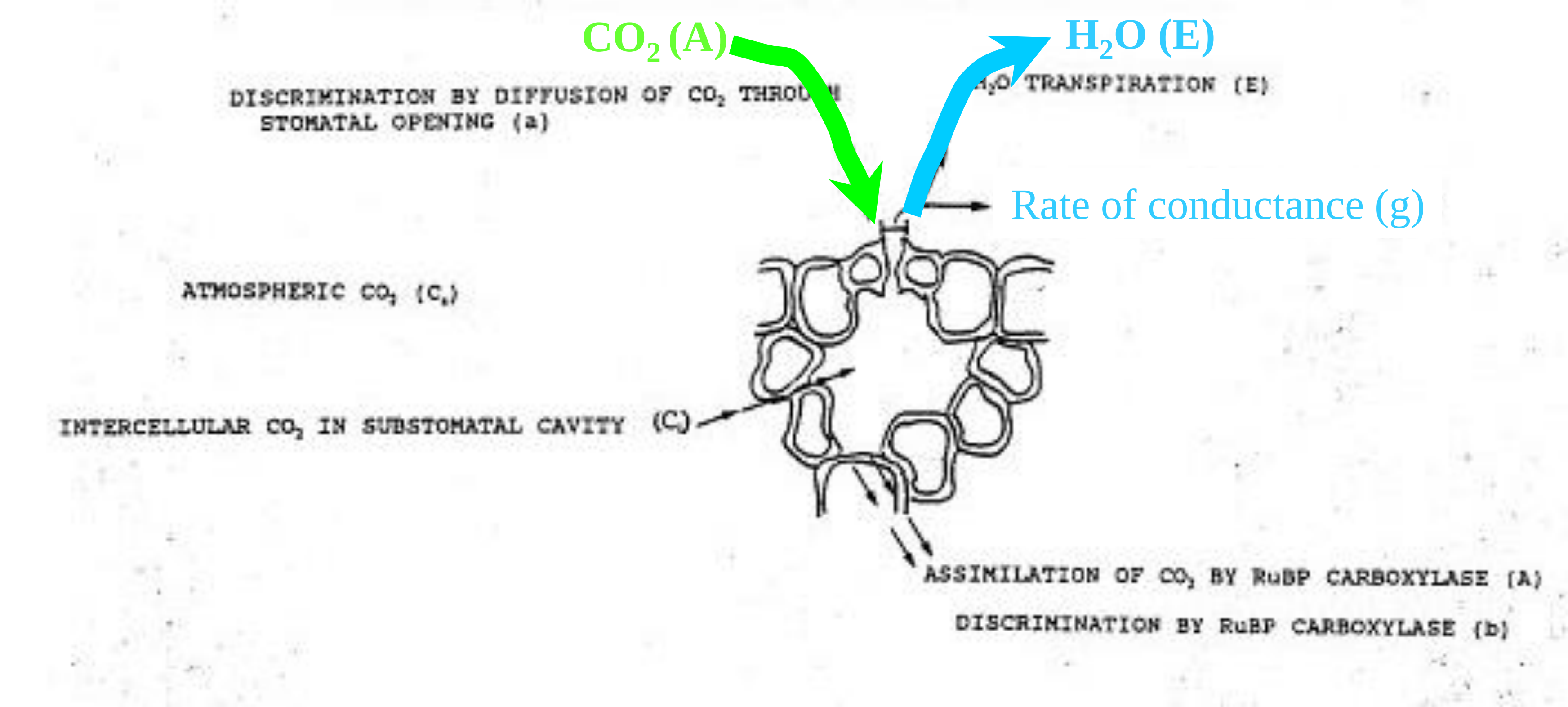
Next, the alteration of C isotopes by fractionation…….

Schematic of relative $\delta^{13}C$ fractionations involved in cellulose synthesis



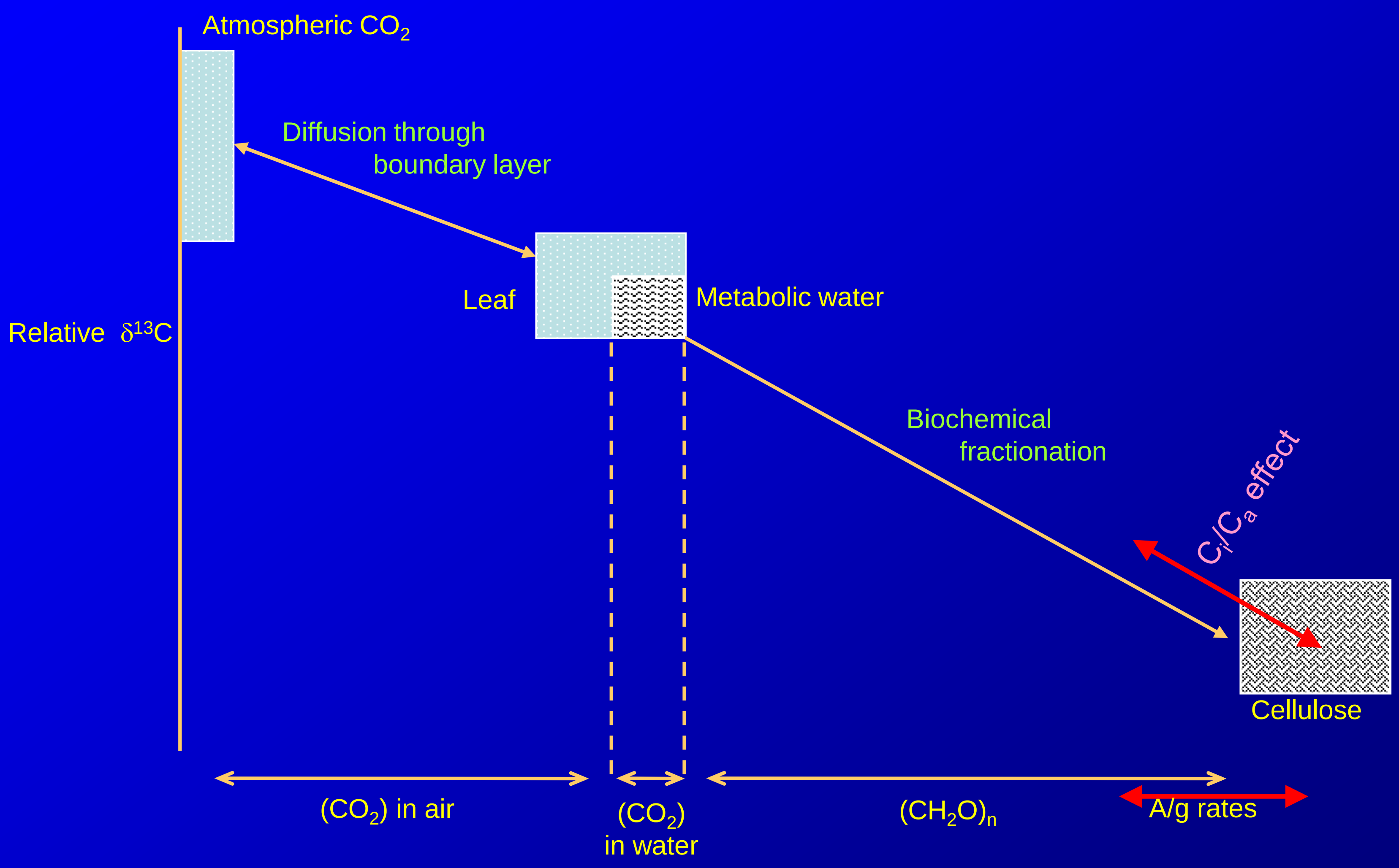
(Modified after Hemming unpublished)

Conductance of CO_2 and Water Vapor through Leaf Stomata



Next, the alteration of C isotopes by fractionation…….

Schematic of relative $\delta^{13}C$ fractionations involved in cellulose synthesis



(Modified after Hemming unpublished)

C Fractionation in C_3 and C_4 Plants

$$\delta^{13}C_{C3\ plant}\ (‰) = \delta^{13}C_{air} - a - (b - a)C_i/C_a$$

$$\delta^{13}C_{C4\ plant}\ (‰) = \delta^{13}C_{air} - a - (b_4 + (b_3 - s)\phi - a)C_i/C_a$$

$$A/g\ (\text{intrinsic water-use efficiency, iWUE}) = (C_a - C_i)/1.6$$

a is the fractionation by diffusion into the stomata (4.4‰),
b and $\boldsymbol{b_3}$ are the fractionation caused by RuBP carboxylation (reported as *ca.* 27-30‰),
$\boldsymbol{C_i}$ is the concentration of CO_2 in the intercellular leaf space, $\boldsymbol{C_a}$ is concentration of CO_2 in air,
$\boldsymbol{b_4}$ is PEP-C fractionation (-5.7‰, temperature-dependent),
s is fractionation from CO_2 diffusion of out of the bundle sheath (1.8‰)
$\boldsymbol{\phi}$ is the fraction of CO_2 fixed by PEP-C that leaks that leaks out of the bundle sheath cells,
A is the assimilation rate, ***g*** is the leaf stomatal conductance to water vapor transfer,
1.6 is the ratio of diffusivities of water vapor and CO_2 in air.

What can we reconstruct from $\delta^{13}C$ in tree rings?............

ENVIRONMENT FROM TREE-RING ISOTOPES

Reported tree-ring $\delta^{13}C$–temperature coefficients (irrespective of significance). Most studies analyzed cellulose. "+" or "–" only indicated where magnitude was not specified.

Trees	Reference	$\Delta\delta^{13}C/\Delta T$ (‰/°C)
Populus	Lerman (1974)	**–0.1**
Quercus	Libby & Pandolfi (1974)	**+2.0→+2.7**
Athrotaxis	Fraser *et al.* (1976)	**+0.4**
Athrotaxis	Pearman *et al.* (1976)	**+0.24→+0.48**
Pinus radiata	Wilson & Grinsted (1977)	**+0.2**
Ulmus americana	Farmer (1979)	**–0.7**
Pinus sylvestris	Harkness & Miller (1980)	**–10.2**
Quercus	Tans & Mook (1980)	**+0.27→+0.39**
Juniper monosperma	Leavitt & Long (1982)	**–0.27**
Pinus silvestris	Freyer & Belacy (1983)	**+0.18**
Juniperus	Leavitt & Long (1983)	**–0.24→–0.27**
Coniferae	Stuiver & Braziunas (1987)	**+0.32**
Diplotaxis erucoides	Schleser *et al.* (1989)	**+0.33**
Pinus ponderosa	Leavitt & Long (1991)	**–**
Abies alba	Lipp *et al*. (1991)	**+0.33**
***Pinus silvestris* L.**	Hemmann (1993)	**+0.35**
***Fagus sylvatica* L.**	Dupouey *et al*. (1993)	**+0.25**
Abies alba	Lipp *et al*. (1994)	**+0.26**
Quercus	Ogle & McCormac (1994)	**+**
Quercus petraea	Switsur *et al*. (1995)	**+0.30**
***Pinus silvestris* L.**	Sonninen & Junger (1995)	**+0.10**
Cryptomeria japonica	Matsumoto & Kitigawa (1995)	**–0.29**
Pinus koraiensis	Park *et al.* (1995)	**–**
Fagus silvatica	Saurer *et al.* (1995)	**+0.34→+0.36**
Abies Kawakamii	Sheu *et al.* (1996)	**–0.46**
***Quercus robur* (Finland)**	Roberston *et al.* (1997a)	**+**
***Quercus robur* (England)**	Robertson *et al.* (1997b)	**+**
Quercus/Fagus/Pinus	Hemming et al. (1998)	**+**

(Updated from Hemming,1998)

Evidence of Moisture Availability Influence on $\delta^{13}C$

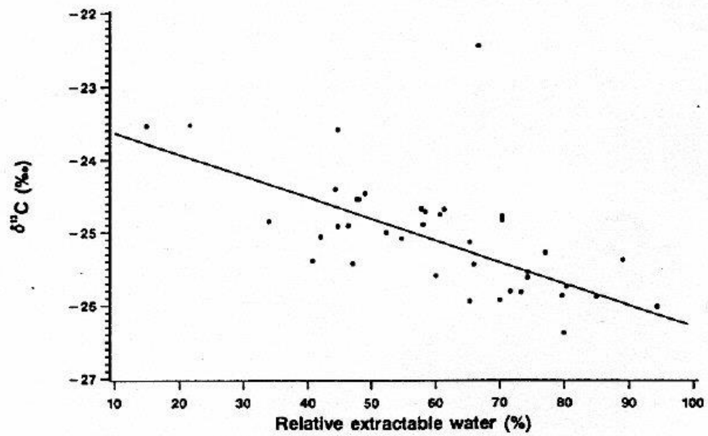


Figure 3. Relationship between $\delta^{13}C$ and relative extractable soil water of July for 1950 to 1990. Straight line: same remarks as in Fig. 1 ($r = -0{\cdot}77^{***}$).

(Dupouey *et al.*, 1993)

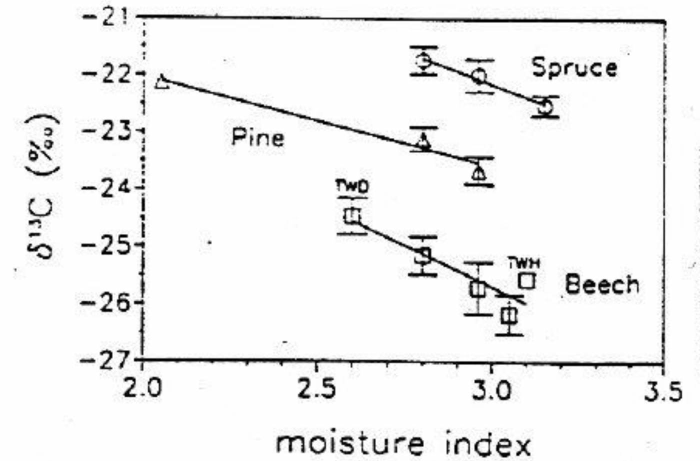


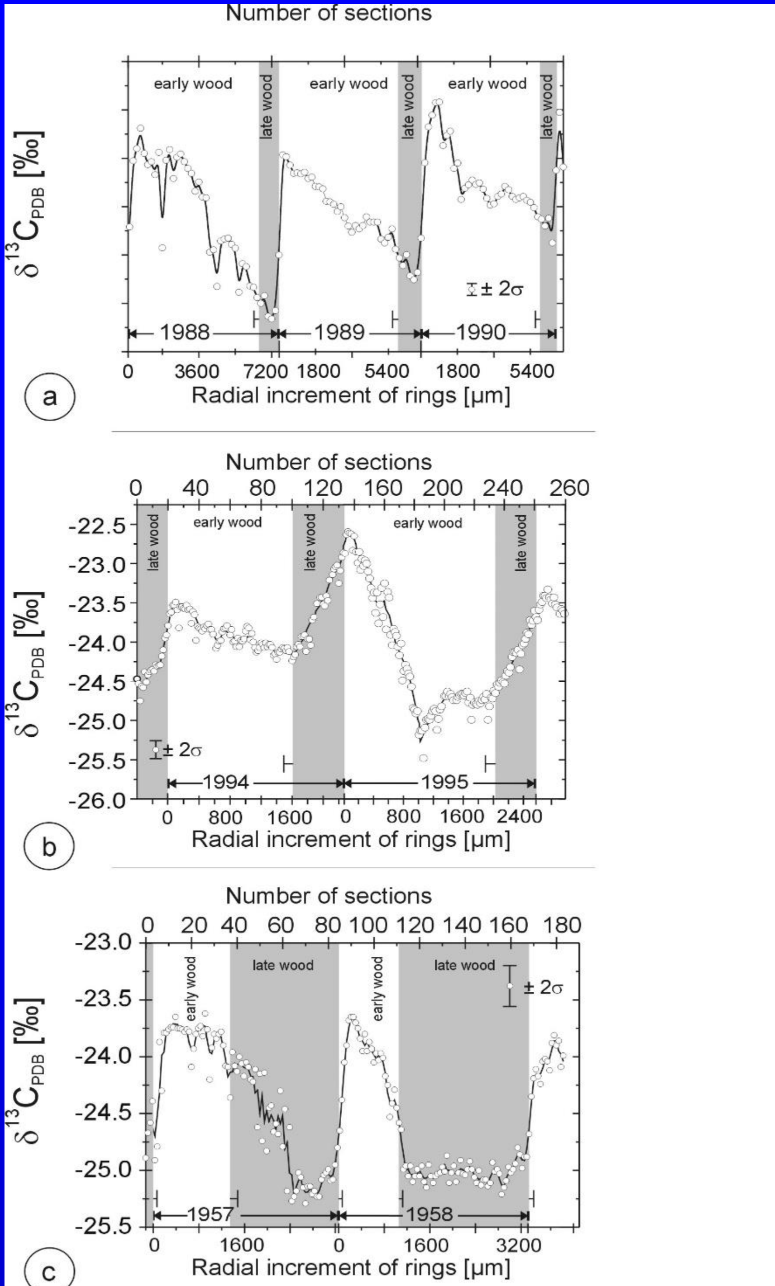
Fig. 6. Mean site $\delta^{13}C$ values for beech (*Fagus silvatica*, □, $n = 6$), spruce (*Picea abies*, ○, $n = 6$) and pine (*Pinus silvestris*, △, $n = 6$) with standard error of the mean (not indicated where smaller than symbol size) versus the moisture index of the sites. All sites are near Court, Swiss Jura (Fig. 1). Indicated are also the corresponding values for the beech trees from the sites "Twann Dry" = TWD and "Twann Humid" = TWH. The solid lines are the regression lines.

(Saurer *et al.*, 1995)

What about seasonal applications?....................

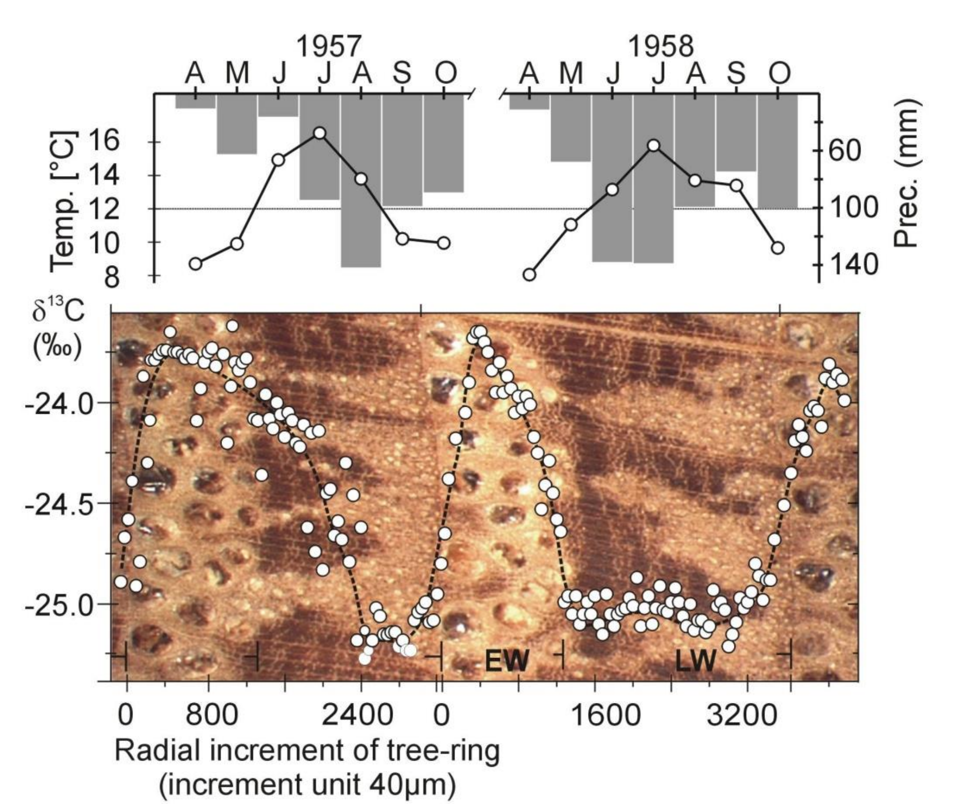
PORTION OF RING ANALYZED

Seasonal variations of tree-ring $\delta^{13}C$ of a) ***Populus nigra***, b) ***Fagus sylvatica*** and c) ***Quercus petraea***.



after Schleser, G. H., Helle, G., Lücke, A. & Vos,H. (1999): Isotope signals as climate proxies - the role of transfer functions in the study of terrestrial archives. QSR, 18: 927-943

Seasonal variations of tree-ring $\delta^{13}C$ of *Quercus petraea*, air temperature and precipitation Rostrevor, N-Ireland

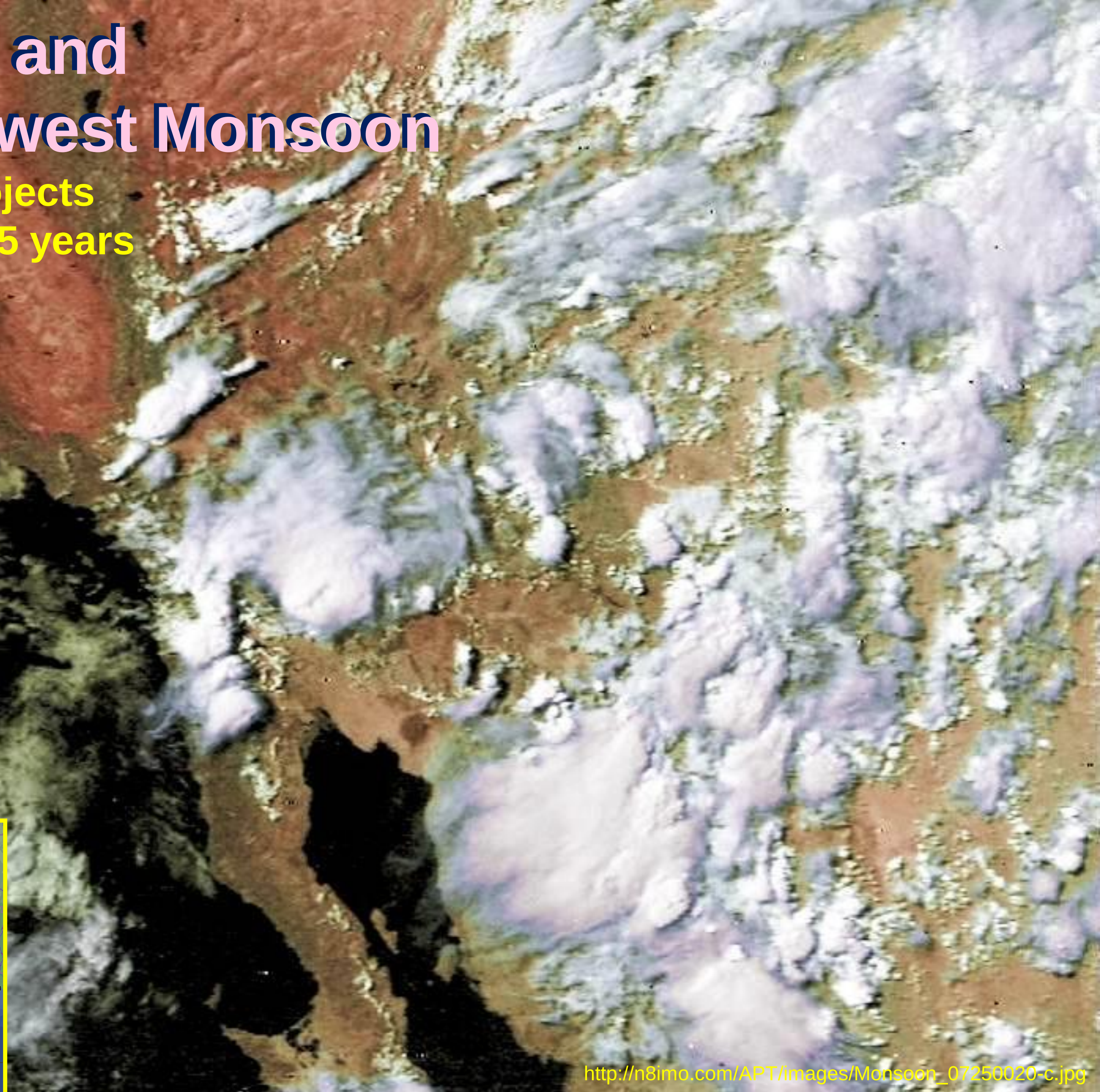


after Schleser, G. H., Helle, G., Lücke, A. & Vos,H. (1999): Isotope signals as climate proxies - the role of transfer functions in the study of terrestrial archives. QSR, 18: 927-943

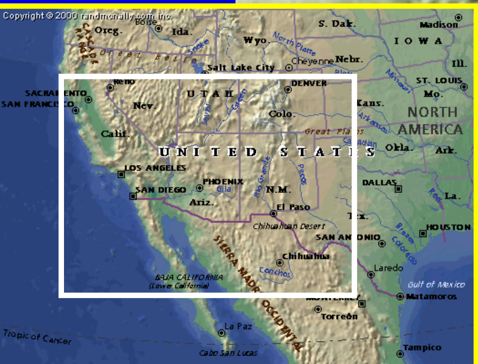
TREE-RING ISOTOPES AND CLIMATE

Tree Rings and U.S. Southwest Monsoon

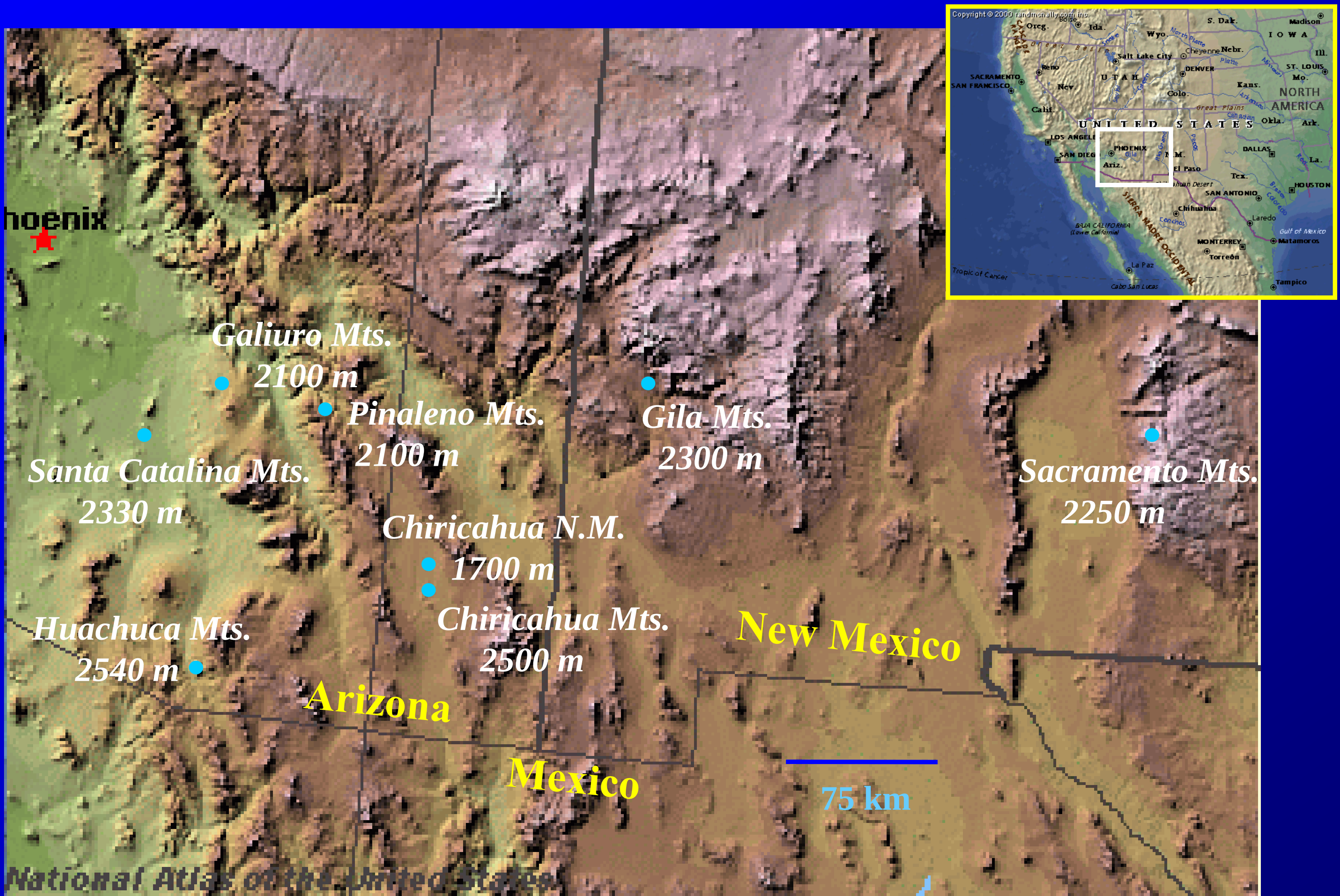
Several LTRR projects over the last 20-25 years

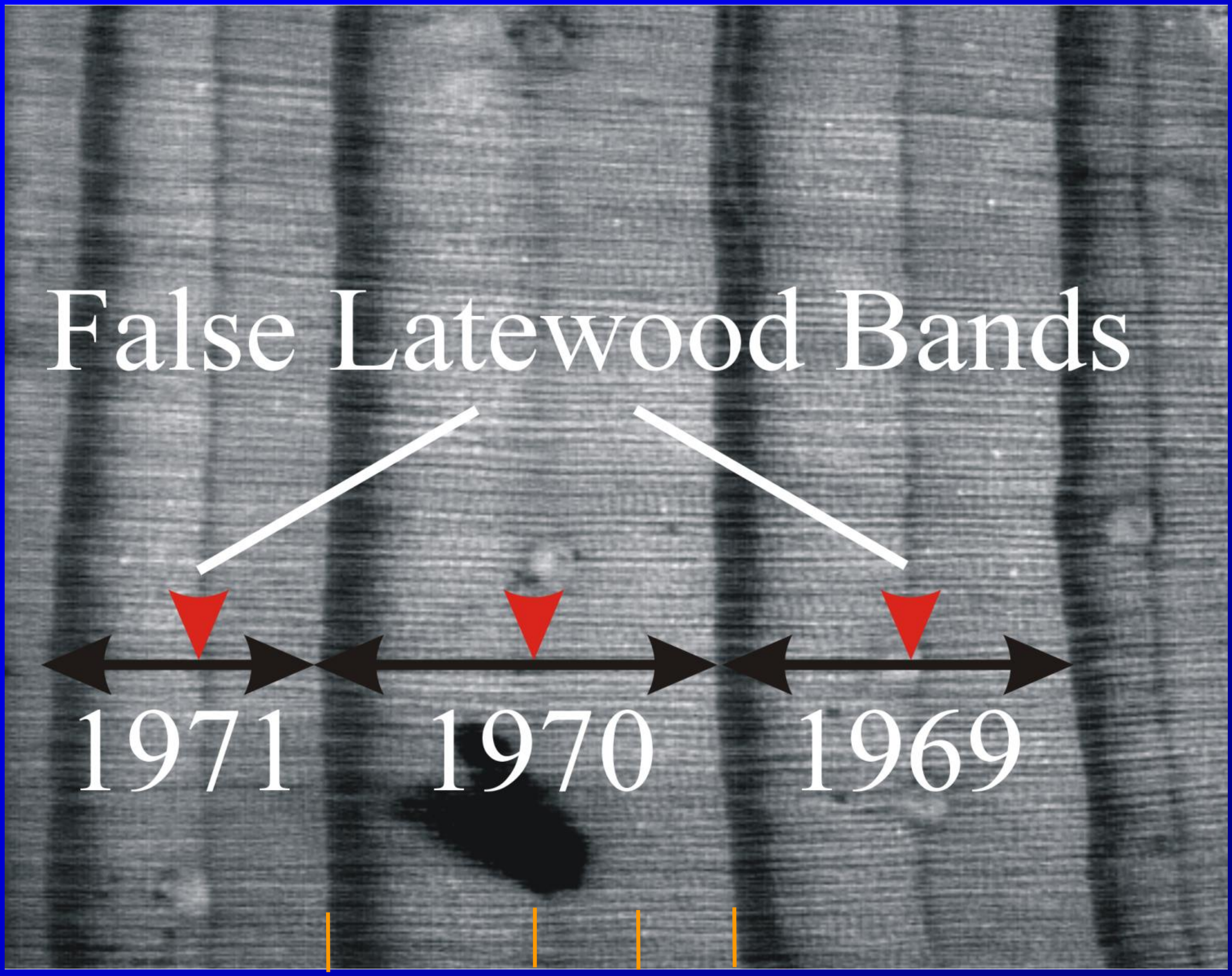


http://n8imo.com/APT/images/Monsoon_07250020-c.jpg

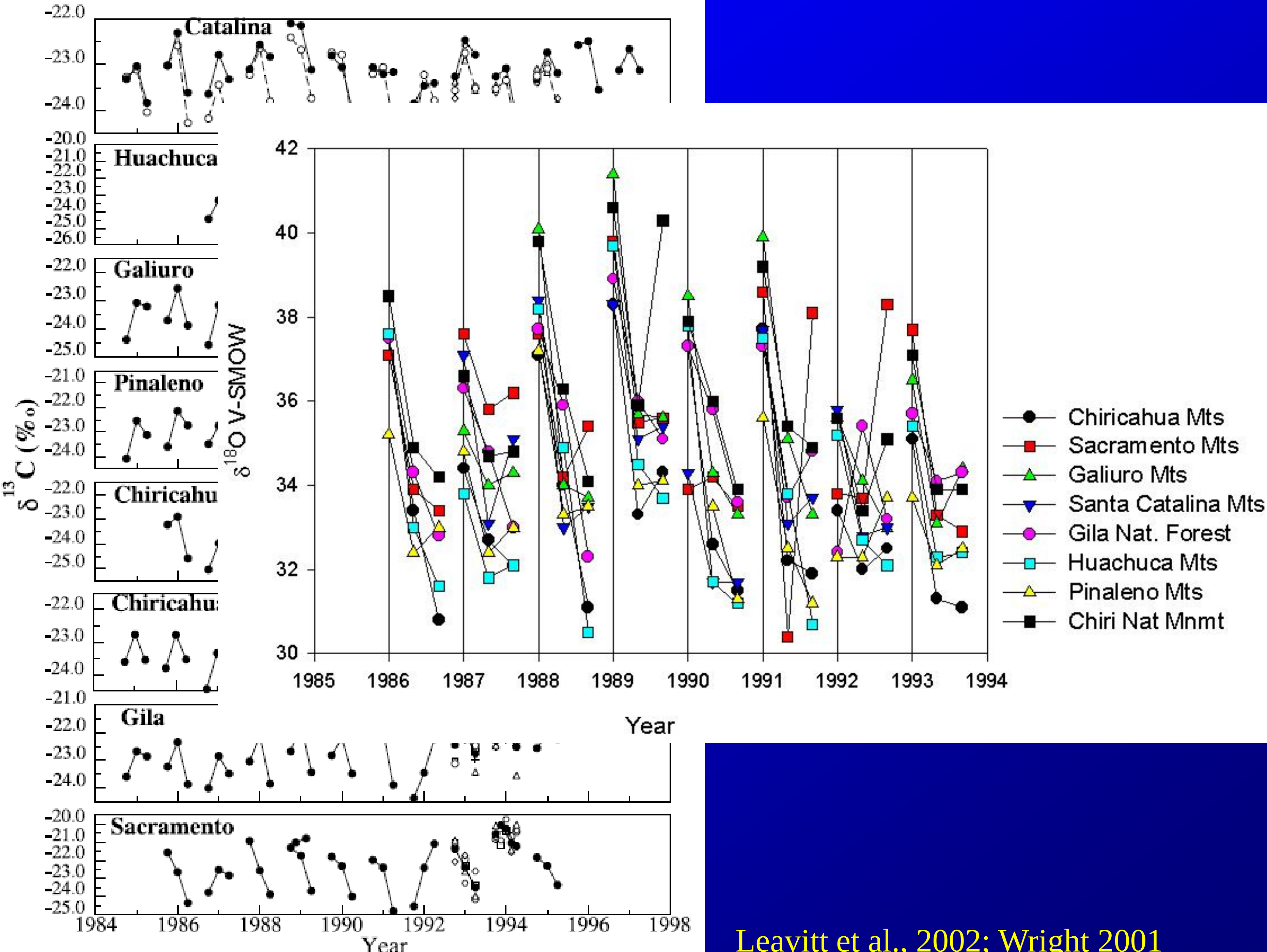


Ponderosa Pine Isotope Network: Seasonal Measurements

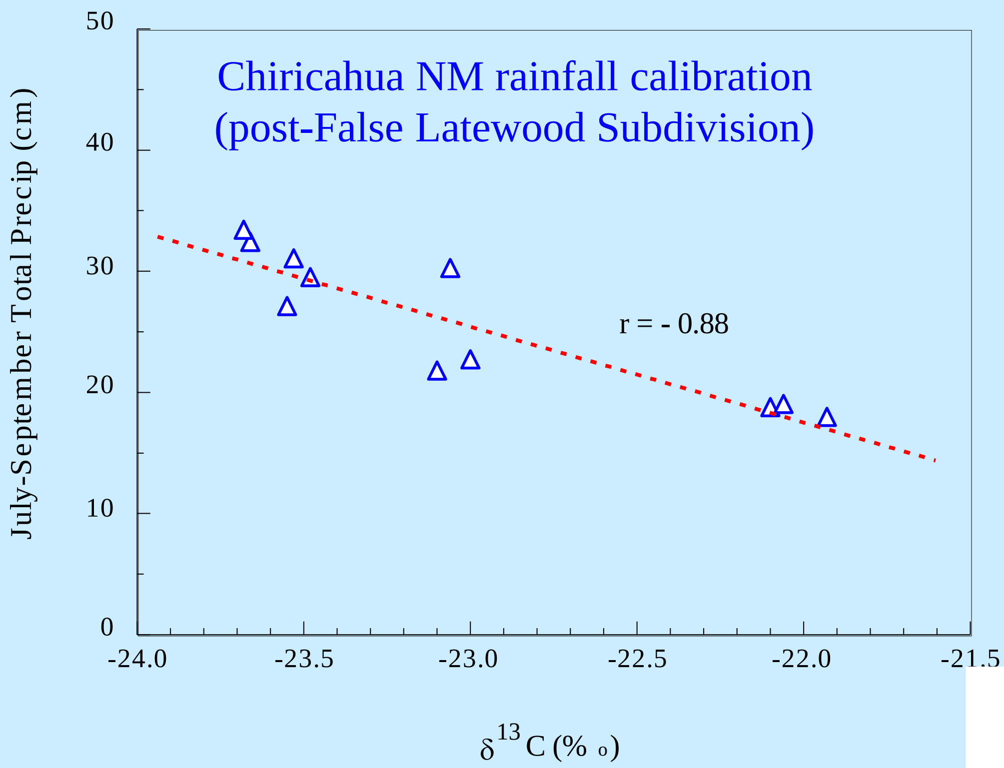




3 Subdivisions:
- Pre-1
- Pre-2
- Post-False Latewood Band

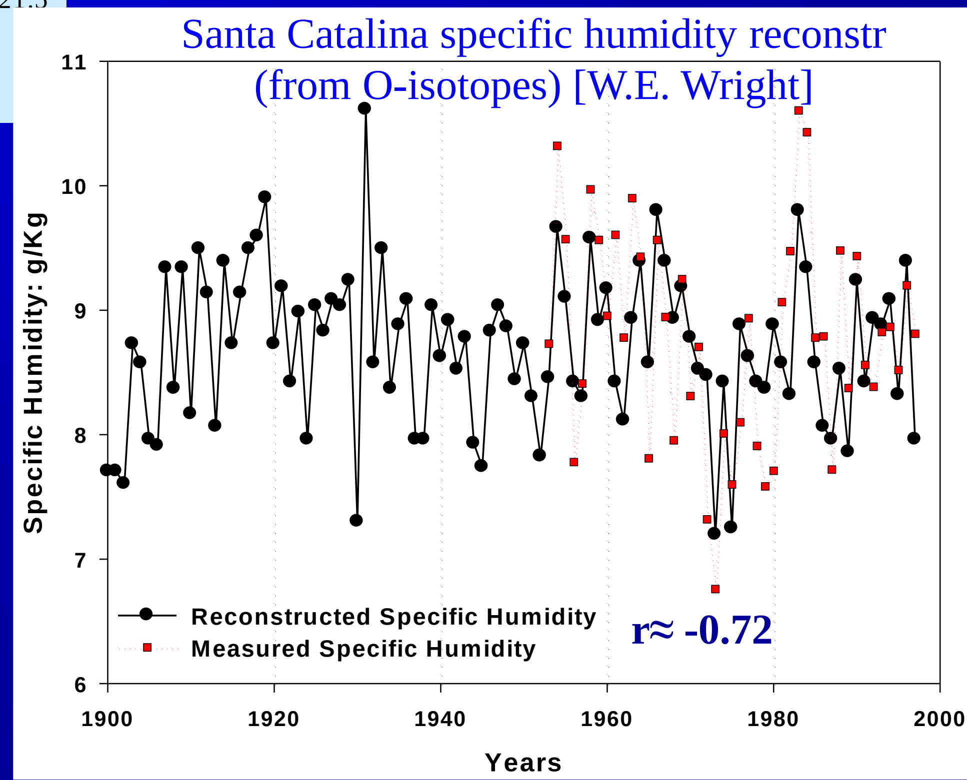


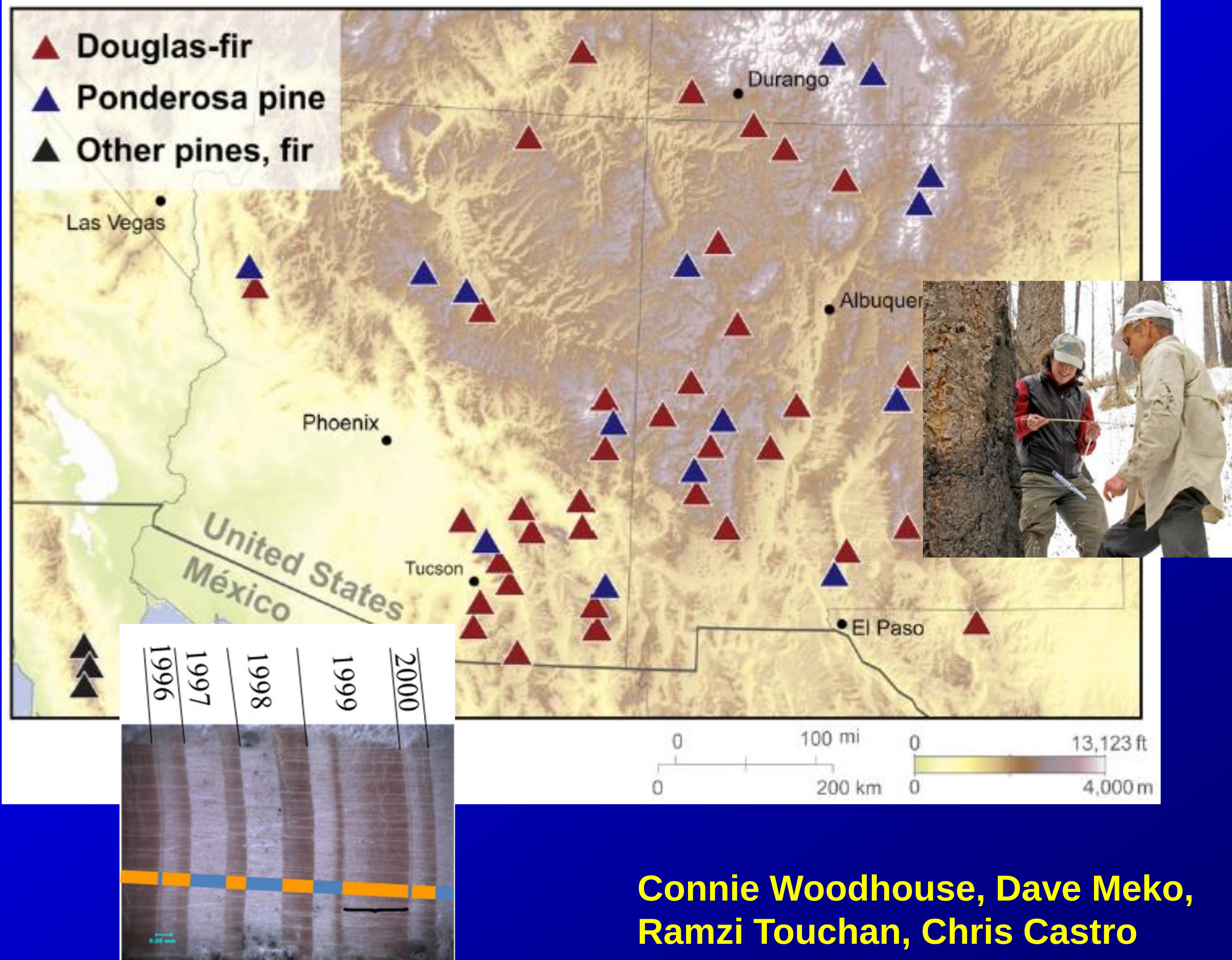
Leavitt et al., 2002; Wright 2001



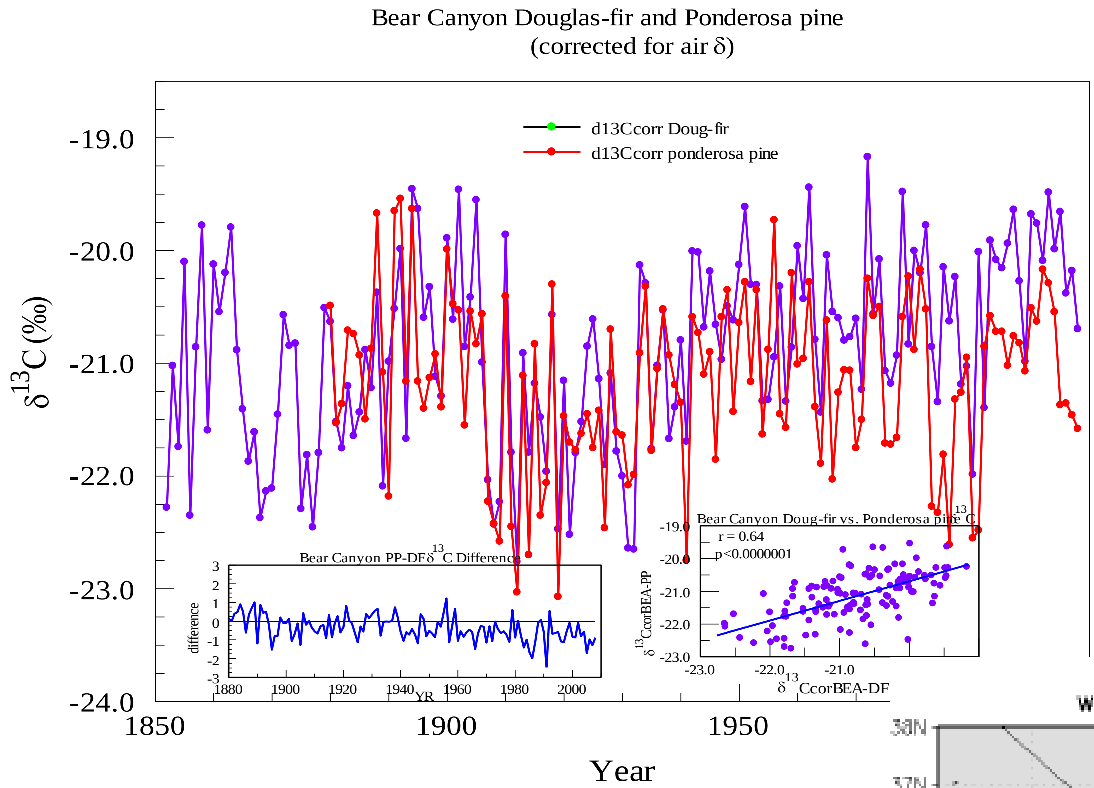
Leavitt et al., 2002

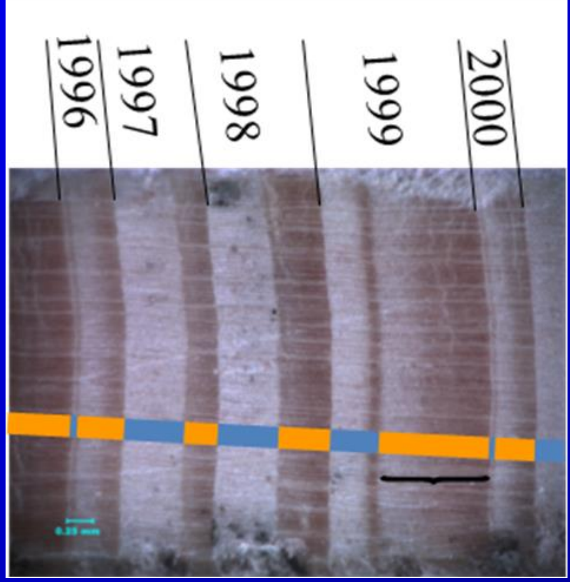
Wright & Leavitt 2006



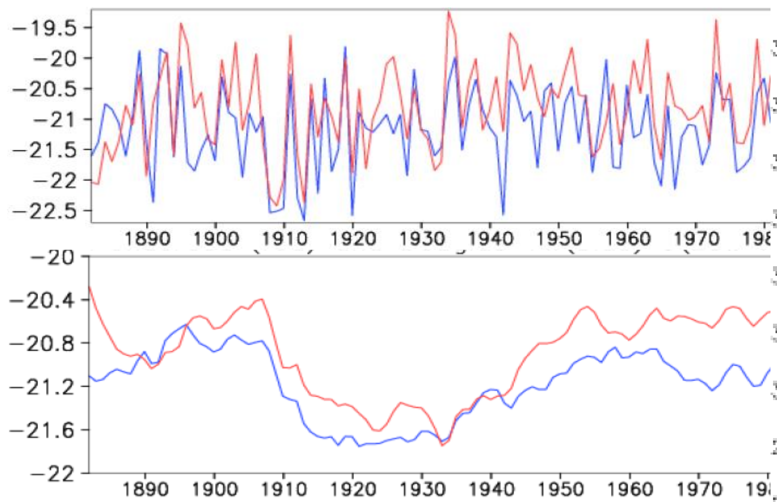


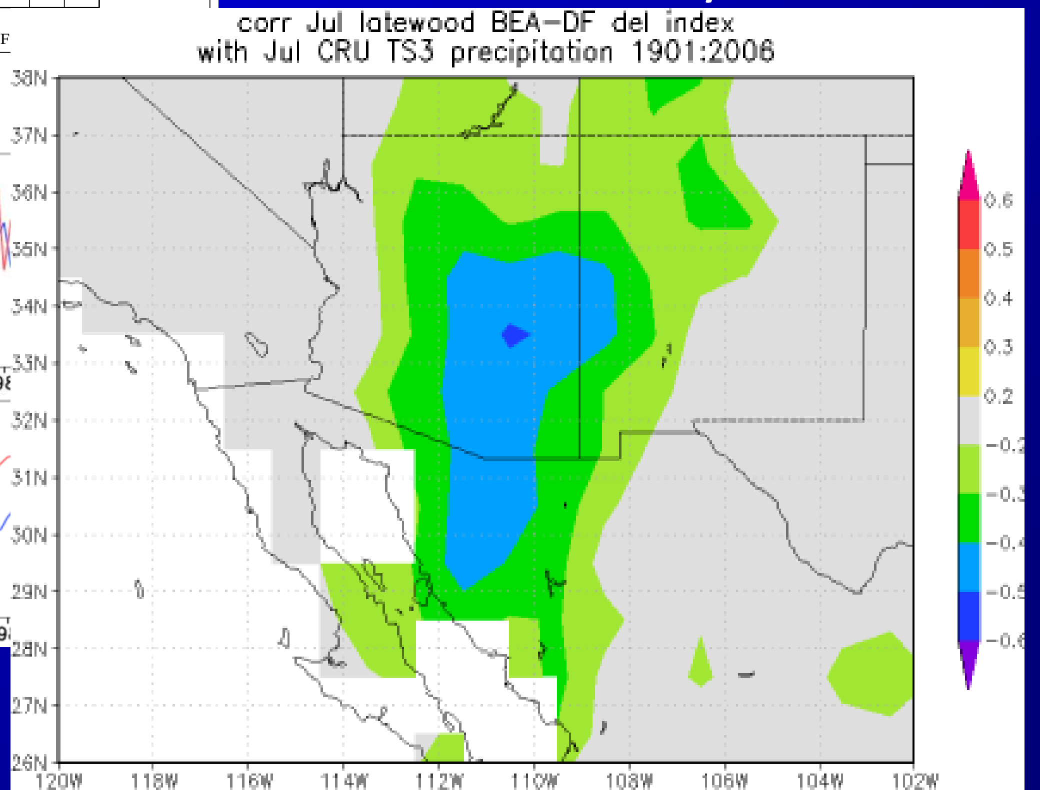
Connie Woodhouse, Dave Meko, Ramzi Touchan, Chris Castro





BearCanyon DF





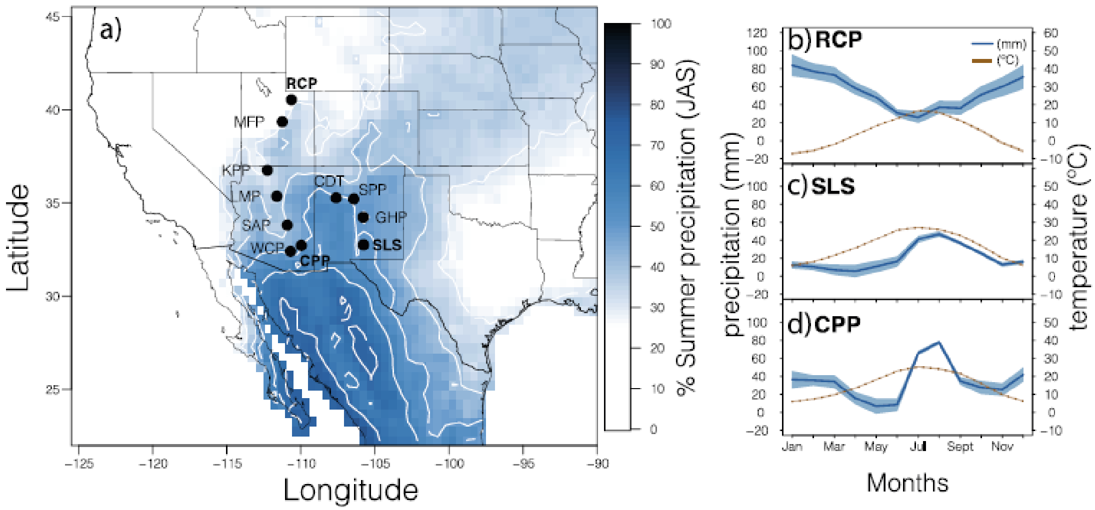


Figure 1. (a) Proportion (in %) of summer (July–September (JAS)) precipitation with respect to the total annual precipitation amount. Darker colors indicate higher summer precipitation proportion. The tree ring network in the U.S. extension of the NAMS is indicated with black dots. Climate diagrams of precipitation (pre) and temperature (tmp) for (b) northern (UT), (c) southeastern (NM), and (d) southwestern (AZ) regions of the NAMS.

Latitudinal gradients in tree ring stable carbon and oxygen isotopes reveal differential climate influences of the North American Monsoon System

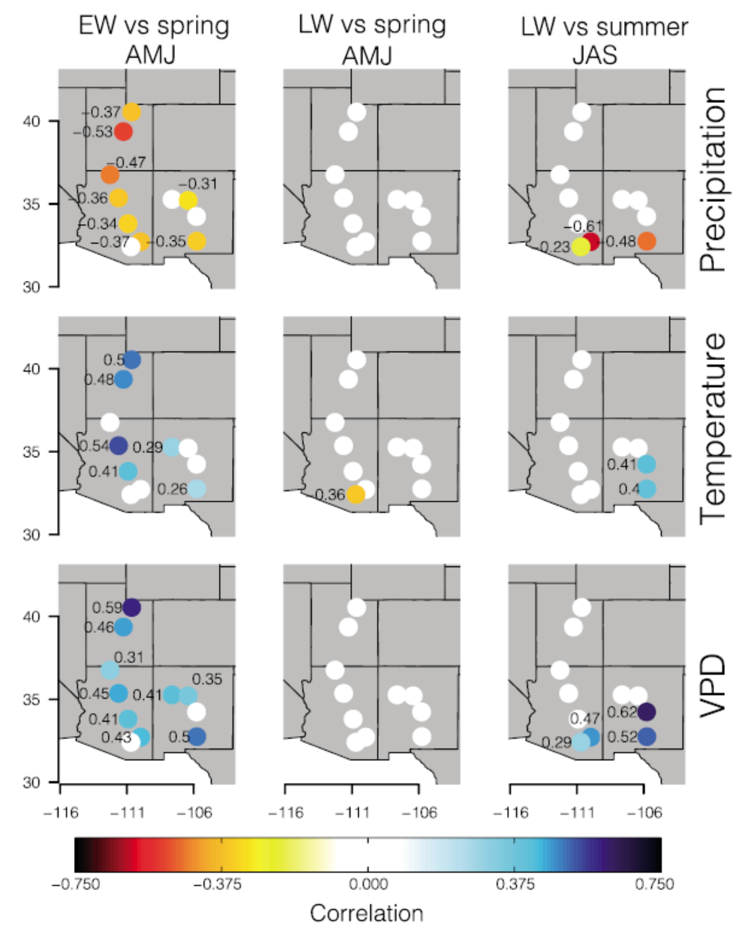
Szejner, P., et al., J. Geophysical Research 2016

Each tree ring from 1960 to 2012 was sliced into three sections: the earlywood, which was split into two halves EW1(first half) and EW2 (second half) and the latewood (LW).

Only EW1 and LW were used for isotopic analysis, with the EW2 subdivision being stored for future analysis.

We assume that EW1 (hereafter referred to as "EW") is a proxy for winter and spring climate and LW is a proxy for summer climate. Each

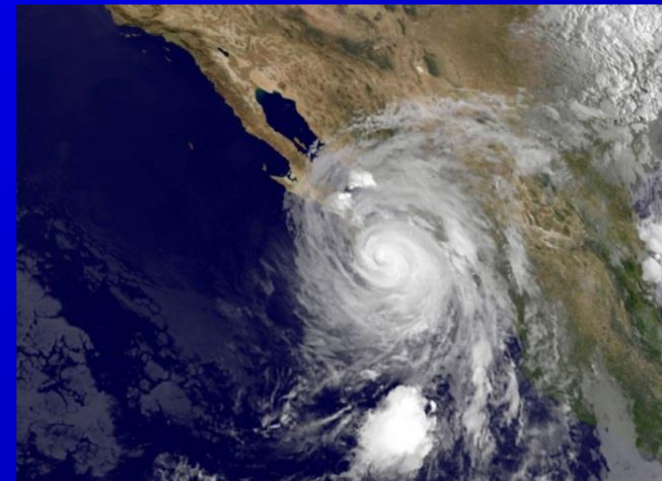
$\delta^{18}O$



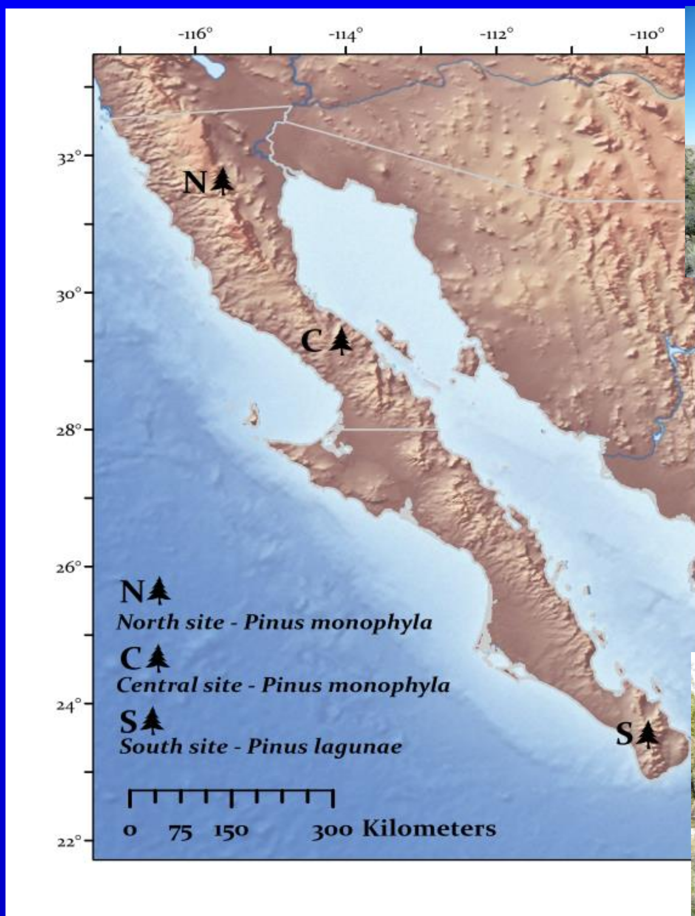
Hydroclimate variability from pinyon in the Baja Peninsula

[UA-UNAM-CONACYT consortium]

José Domingo Carriquiry Beltrán, Valerie Trouet,
Genaro Gutierrez

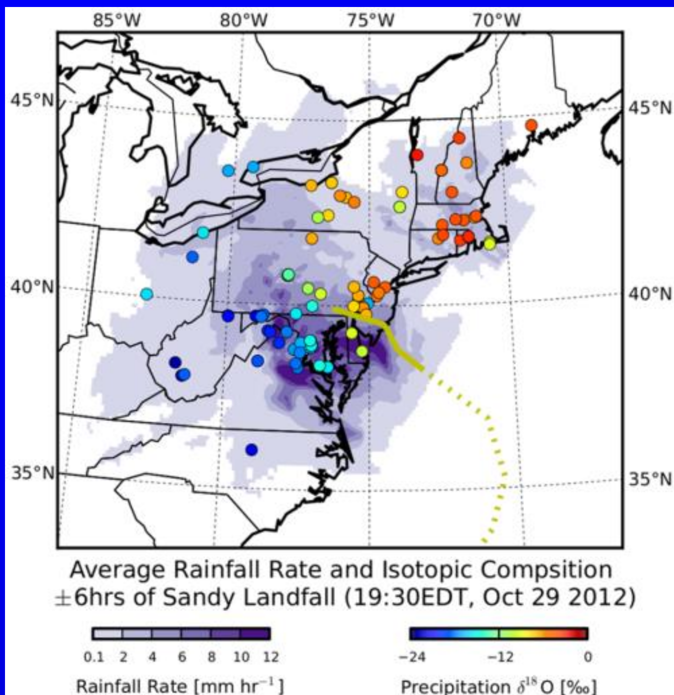


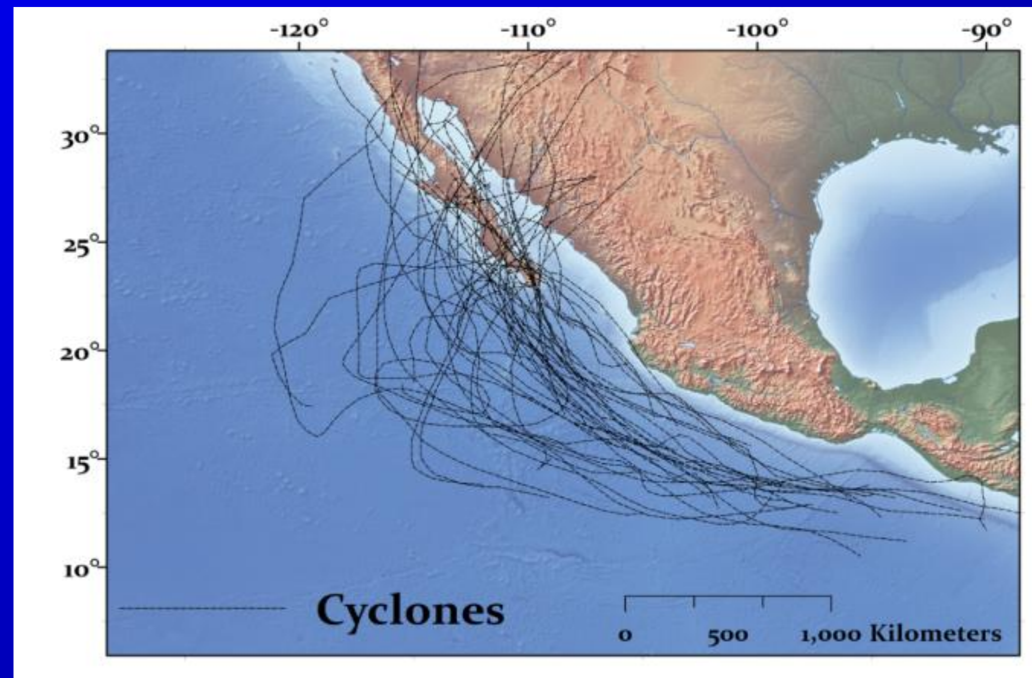
Hurricane Odile
September 2014



Ring widths and isotopes applied to hydroclimate along Baja, California, transect

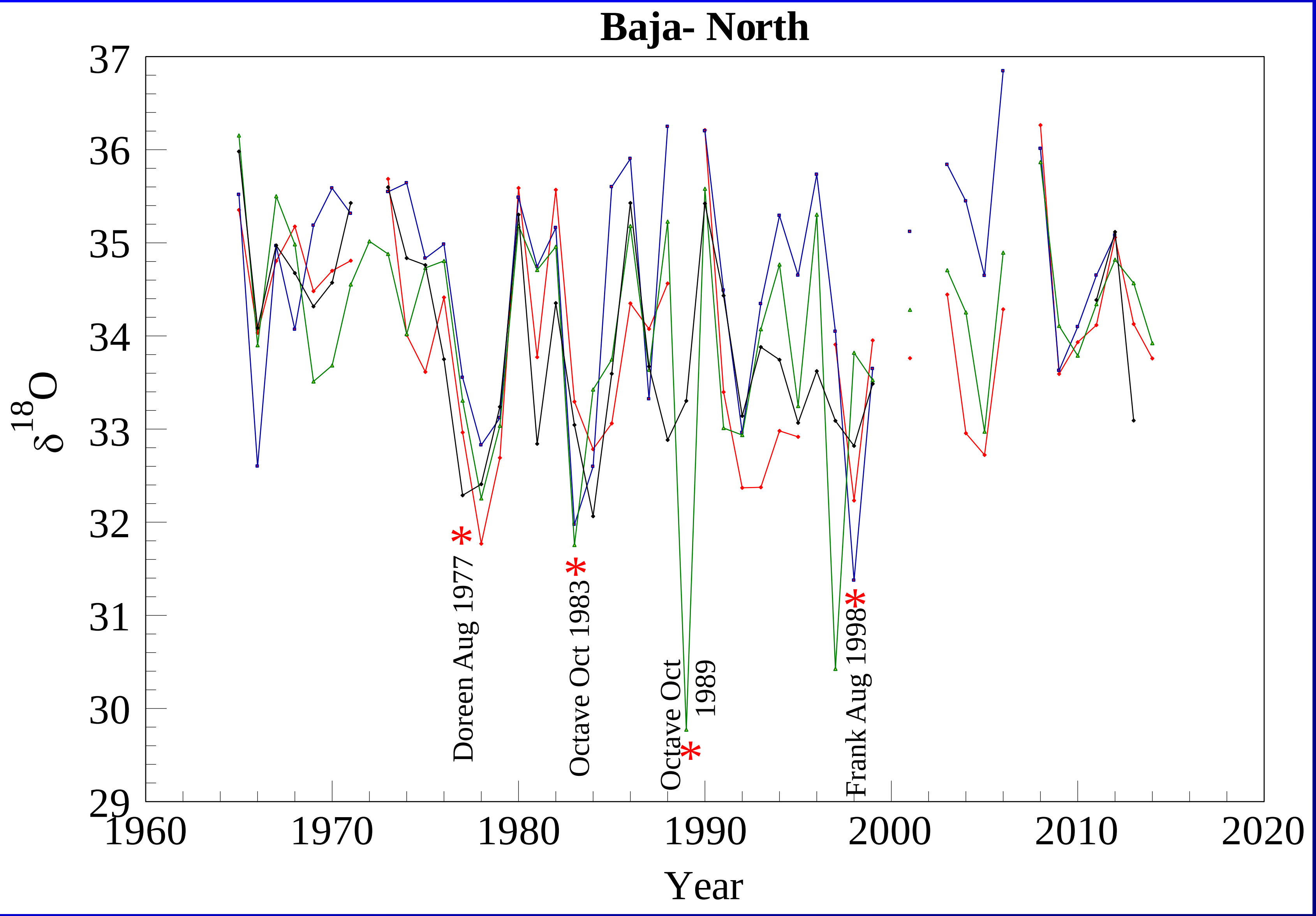
Hydroclimate variability from pinyon in the Baja Peninsula [UA-UNAM-CONACYT consortium]
with
José Domingo Carriquiry Beltrán, Valerie Trouet, Genaro Gutierrez





Hurricane Sandy

Hurricane Carlos
June 2015


Baja- North
37
36
35
34
33
32
31
30
29
$\delta^{18}O$
1960
1970
1980
1990
2000
2010
2020
Year
Doreen Aug 1977
Octave Oct 1983
Octave Oct 1989
Frank Aug 1998

TREE-RING ISOTOPES AND ECOLOGY

Effect of thinning on ponderosa pine stands near Black Butte, OR

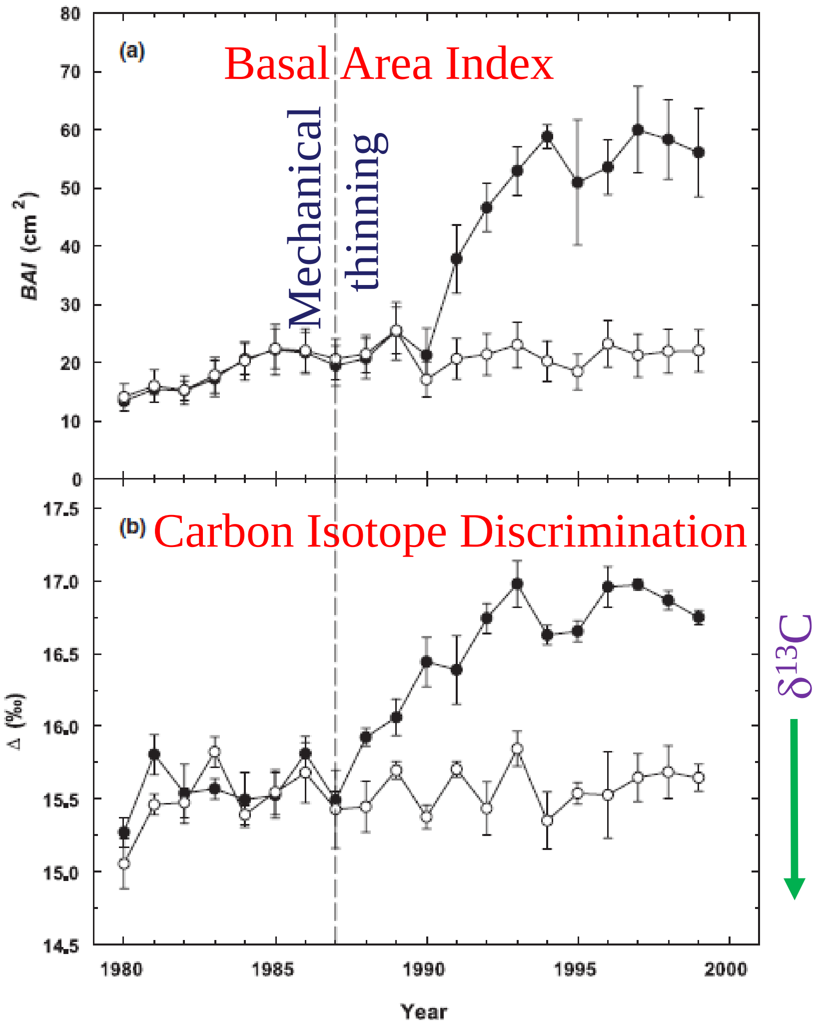


Figure 2. (a) *BAI* and (b) Δ of trees from the paired thinned and control portions of stand A. Trees from the thinned stand are indicated by closed symbols and from the control stand are indicated by open symbols. The date of thinning is indicated by the dashed line. Values are means with standard errors.

Interpreted as an effect of increased water availability

McDowell et al., PCE 2003

TREE-RING ISOTOPES AND ARCHAEOLOGY

Pergamon
Geochimica et Cosmochimica Acta, Vol. 60, No. 17, pp. 3305–3309, 1996

0016-7037/96 $15.00 + .00
PII S0016-7037(96)00166-4

Climatic effects on the $\delta^{18}O$ and $\delta^{13}C$ of cellulose in the desert tree *Tamarix jordanis*

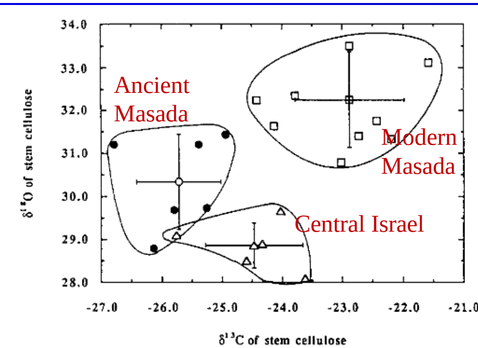
Pergamon
Geochimica et Cosmochimica Acta, Vol. 58, No. 16, pp. 3535–3539, 1994

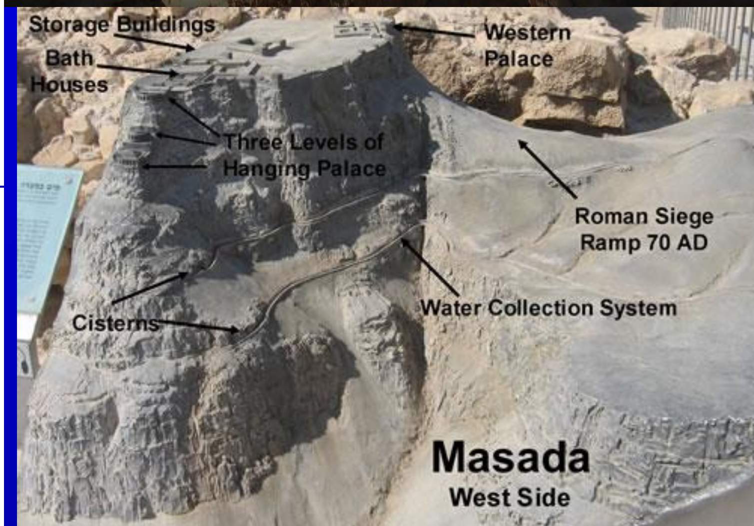
0016-7037/94 $6.00 + .00
0016-7037(94)00130-8

LETTER

^{13}C and ^{18}O of wood from the Roman siege rampart in Masada, Israel (AD 70–73): Evidence for a less arid climate for the region

DAN YAKIR,[1,*] ARIE ISSAR,[2] JOEL GAT,[1] EILON ADAR,[2] PETER TRIMBORN,[3] and JOSEPH LIPP[3]





The isotopic ratios and of cellulose from tamarix trees which were used by the Roman army as a groundwork of the siege-rampart of Masada (ad 70–73) were compared with ratios measured in present-day tamarix trees growing in the Masada region and in central Israel. The ancient tamarix cellulose is depleted in both 13C and 18O compared to cellulose from trees growing in the Masada region today. Similar trends were observed on comparing modern tamarix trees growing in the Negev Desert with those growing in the temperate climate of central Israel. Considering the factors that can contribute to the observed changes in isotopic composition, we conclude that the ancient trees enjoyed less arid environmental conditions during their growth compared to contemporary trees in this desert region. This report demonstrates the potential in using combined 18O and 13C analyses of archeological plant material as independent indication of regional climatic change in desert areas (where conventional isotopic analyses, such as in tree rings, are impractical).

If time,
any questions?