

INTRODUCTION TO TREE RINGS & DENDROCHRONOLOGY



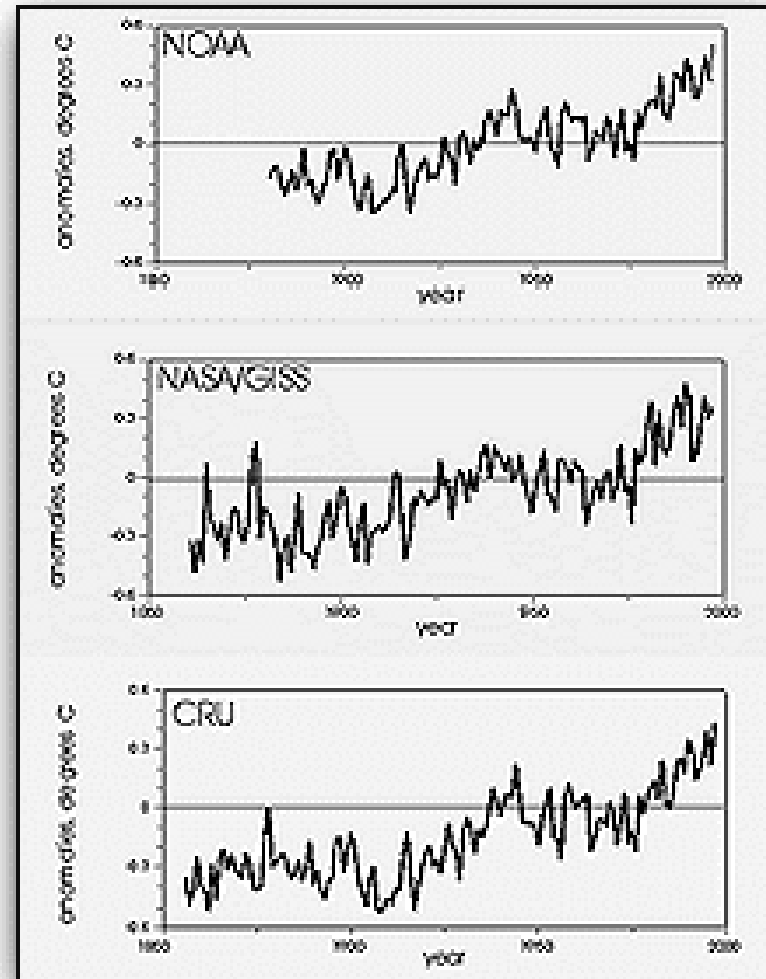
***Trees and stones
will teach you that
which you can
never learn from
masters.***

~ St. Bernard of Clairvaux

DETECTING GLOBAL WARMING:

INSTRUMENTAL RECORD

Thermometer- based Temperature Trends



GLOBAL TEMPERATURE ANOMALIES
SOURCES: NOAA, NASA/GISS, AND CRU



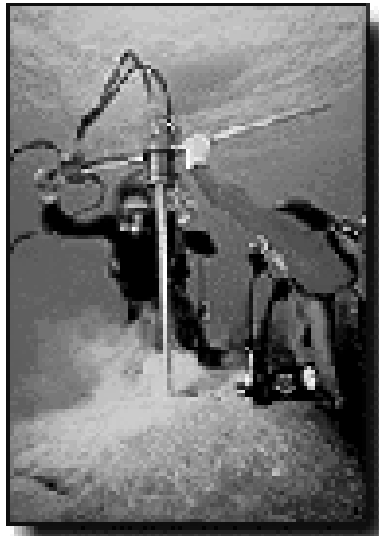
To make an incontrovertible case about the role that humans play in global warming, what do scientists need?

- (a) a long-term temperature record (many centuries)
- (b) that represents a large part of the globe
- (c) so we can look over the long term record and say, “What's the average been for several hundred years, and is recent warming a significant departure from that average?”

So how do we get long-term temperature records?



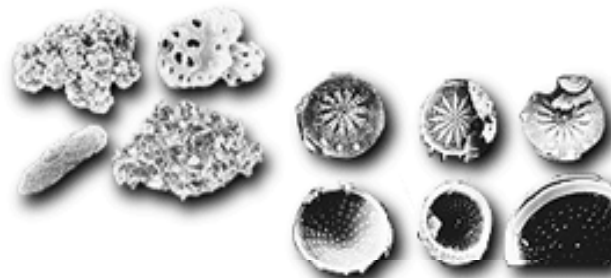
FROM TOOLS CALLED: “PROXY” DATA *or* “NATURAL ARCHIVES” of CLIMATE



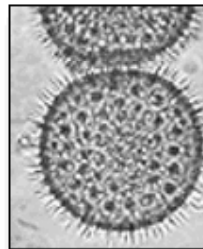
Corals



Ice cores



**Lake, bog &
ocean
sediments**



Pollen



Tree rings!

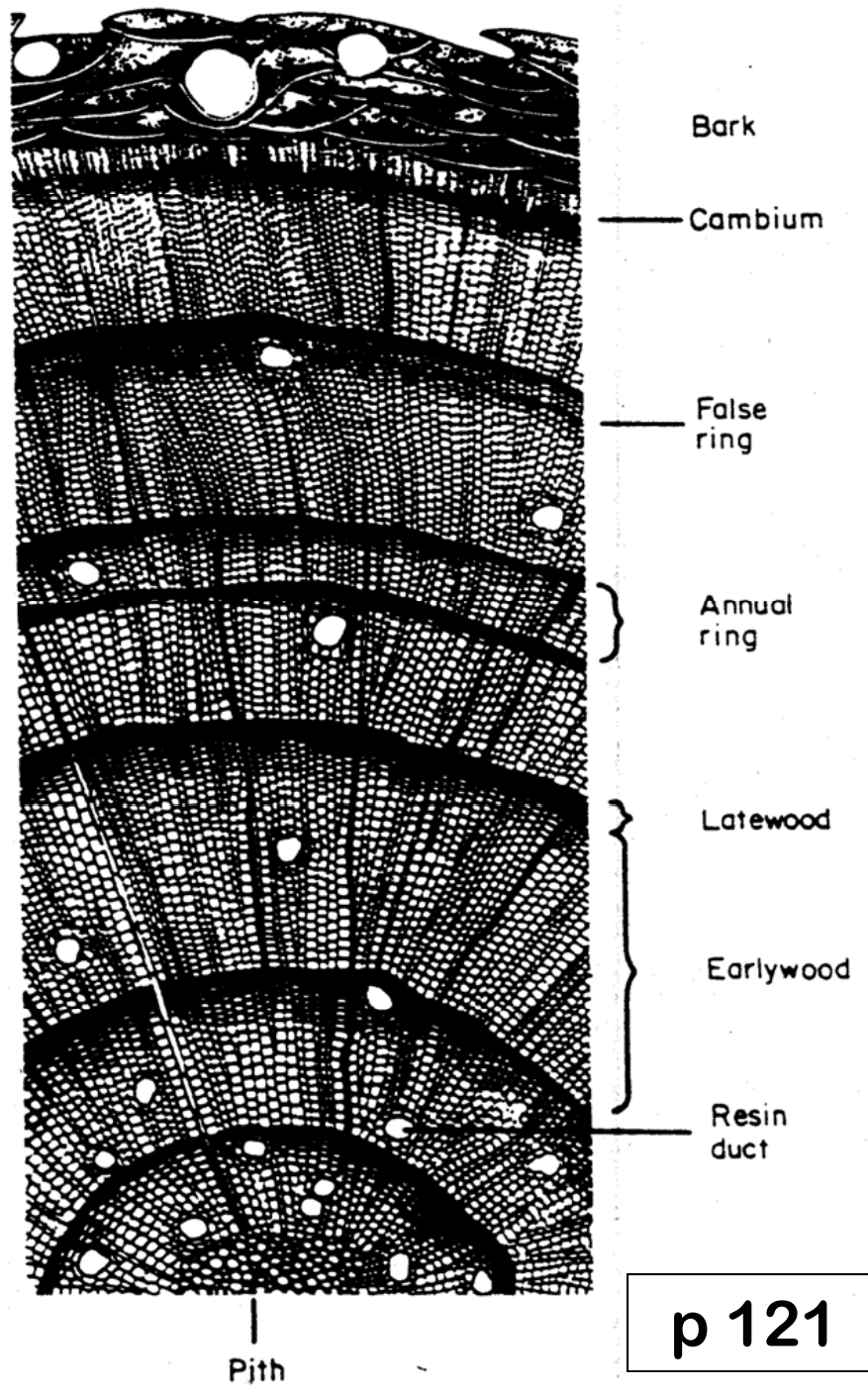
Dendrochronology is the dating and study of annual rings in trees:

- ***chronos***: time, or more specifically events in past time
- ***dendros***: from trees, or more specifically the growth rings of trees
- ***ology***: the study of . . .

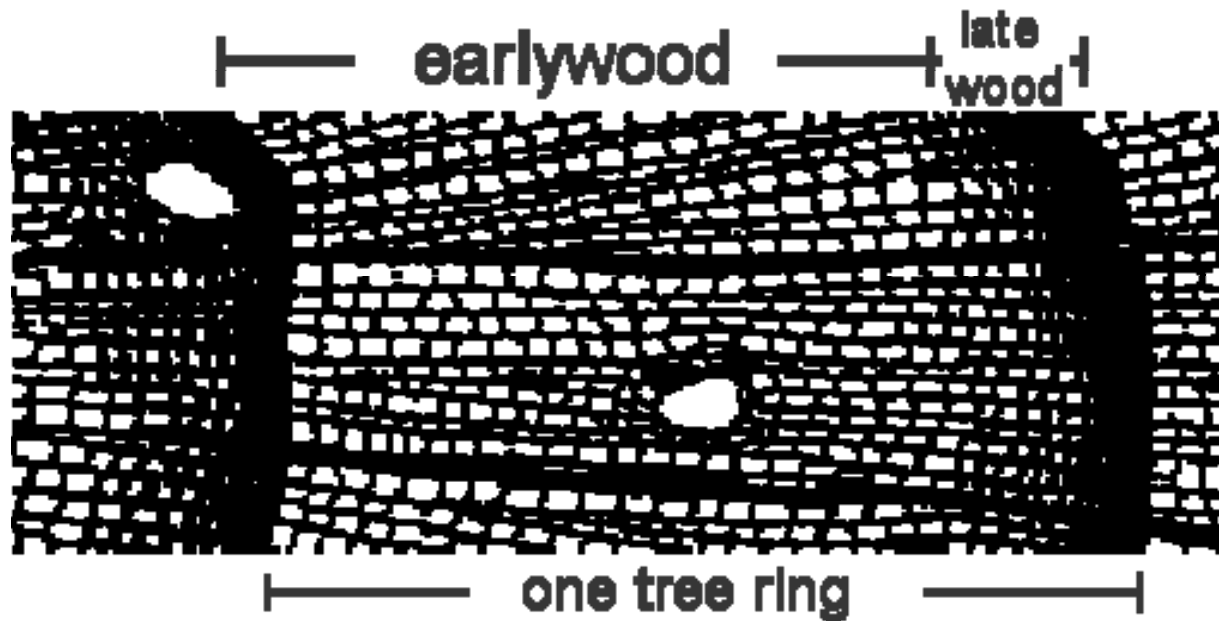
Partial cross-section of a coniferous tree

How old is it?
(in complete years)

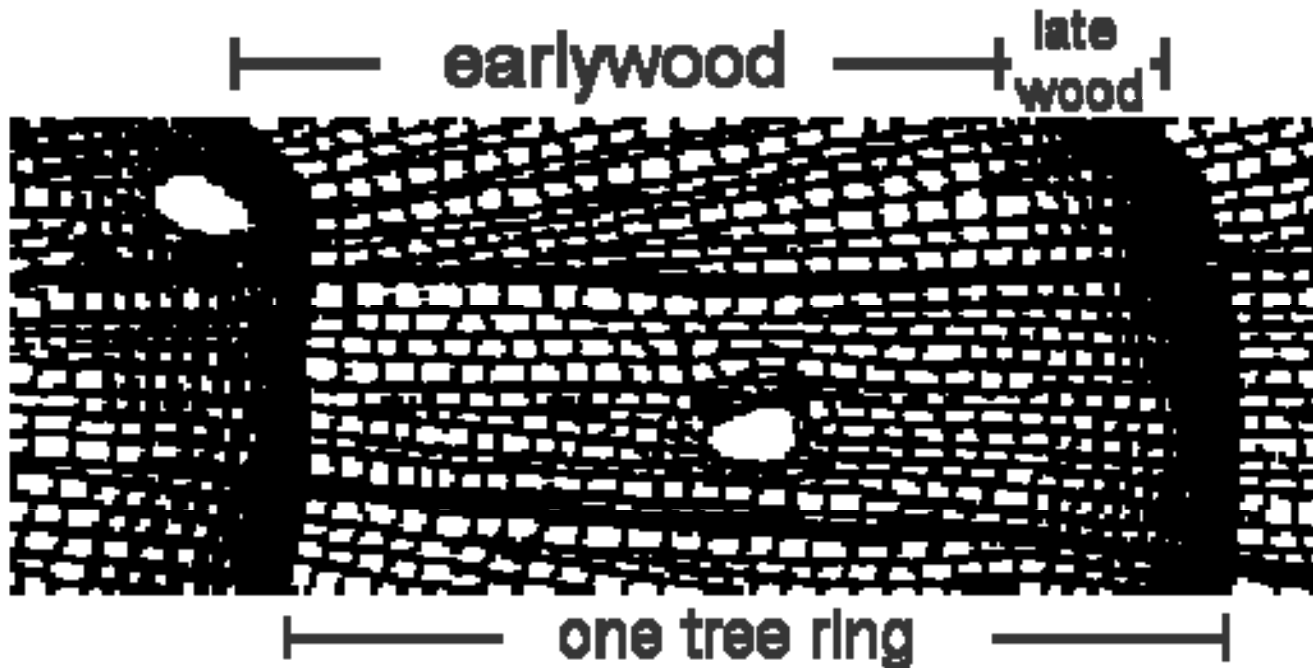
7 years old
(now in 8th year of growth)



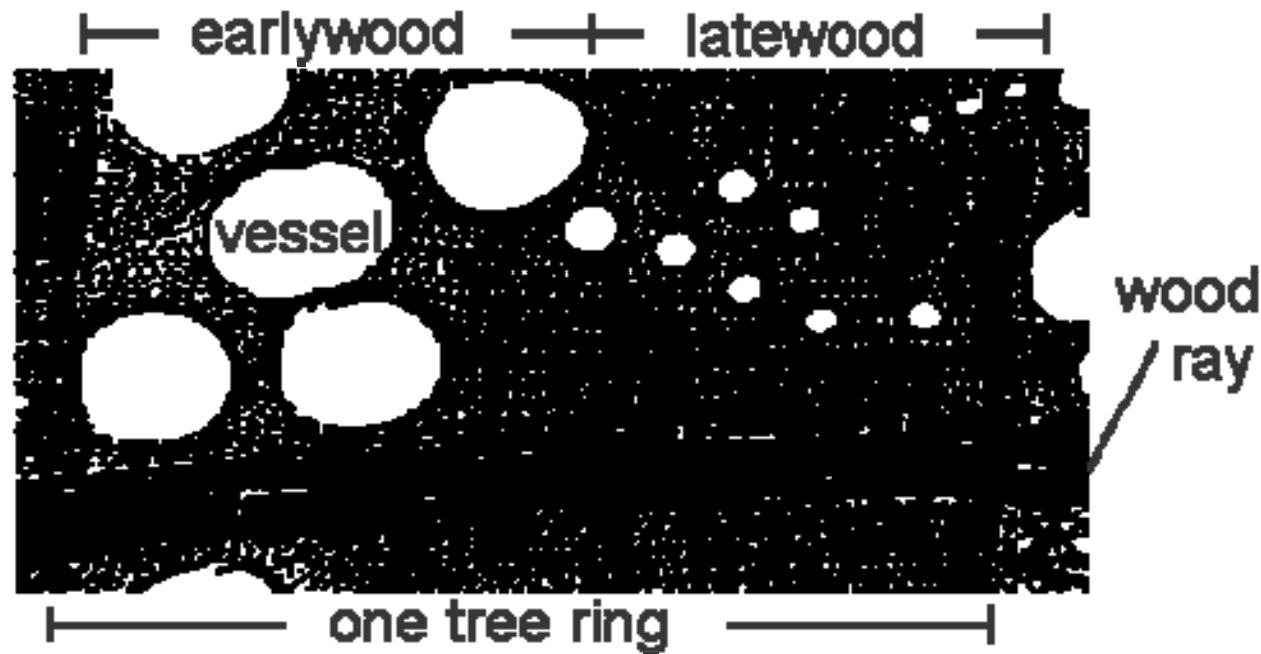
Conifer Tree Ring (cross-section view)



- Earlywood:
 - Cells: thin walls, large diameter
 - Appears light in color
- Latewood:
 - Cells: thick walls, small diameter
 - Appears dark in color



Ring Porous Angiosperm Tree Ring (cross-section, view)



- Earlywood:
 - Cells: large diameter vessels
- Latewood:
 - Cells: small diameter vessels

**But
not all
trees
have
rings!**



The image below shows a conifer tree-ring sample with about thirty rings (every tenth ring is marked) – growing from left to right.

The rings display much variation:



Tree growth (adding new cells) is this way



← Pith
(center of tree)

Bark →
(outside of tree)



Variation in these rings is due to variation in environmental conditions when they were formed.

(cold or warm temperatures / dry or moist soil conditions, etc. – even insect outbreaks and non-climatic factors, too)

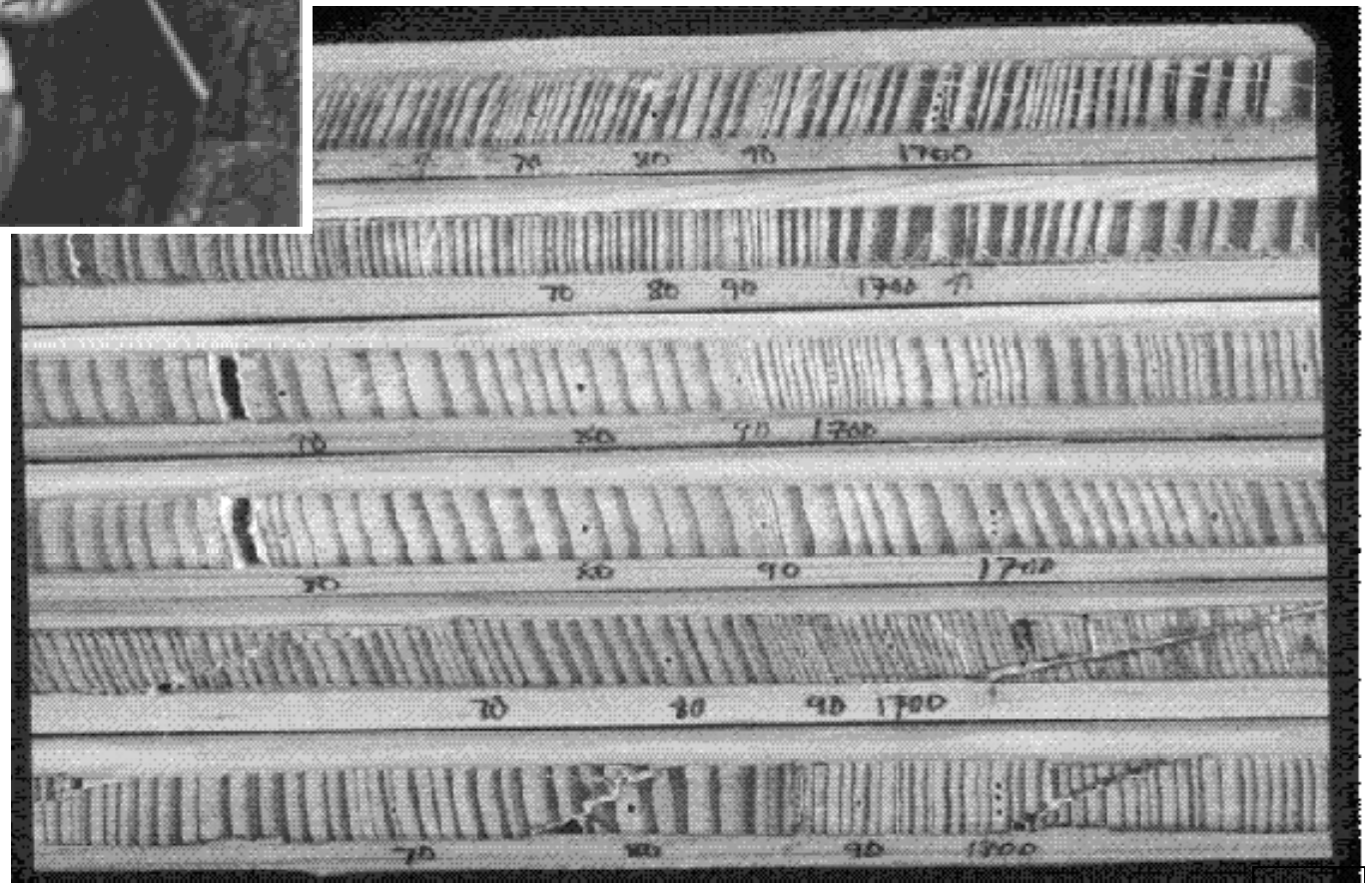
Thus, studying this variation leads to improved understanding of past environmental conditions and is the basis for many research applications of dendrochronology.





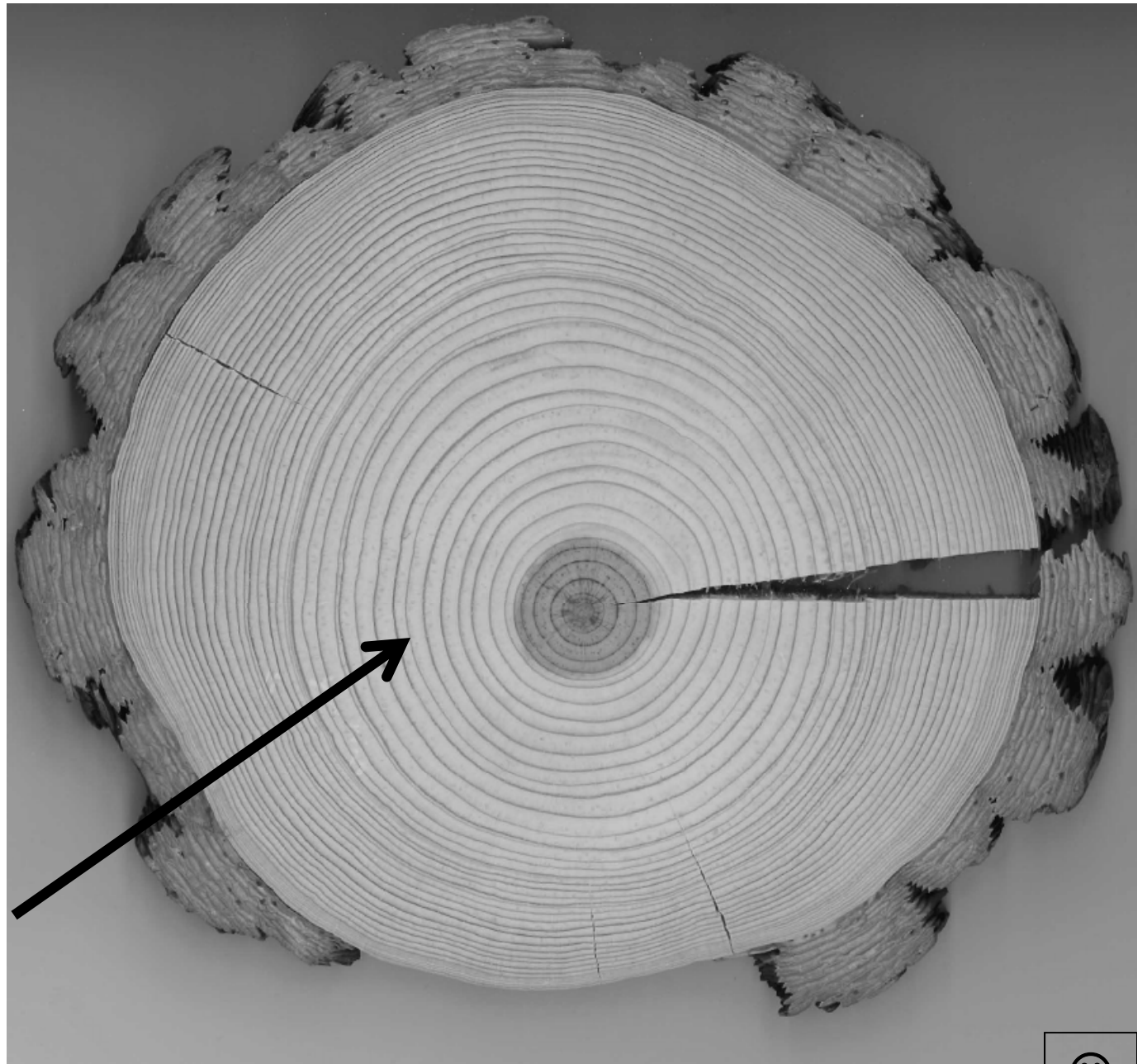
How do we get the tree rings without killing the trees!

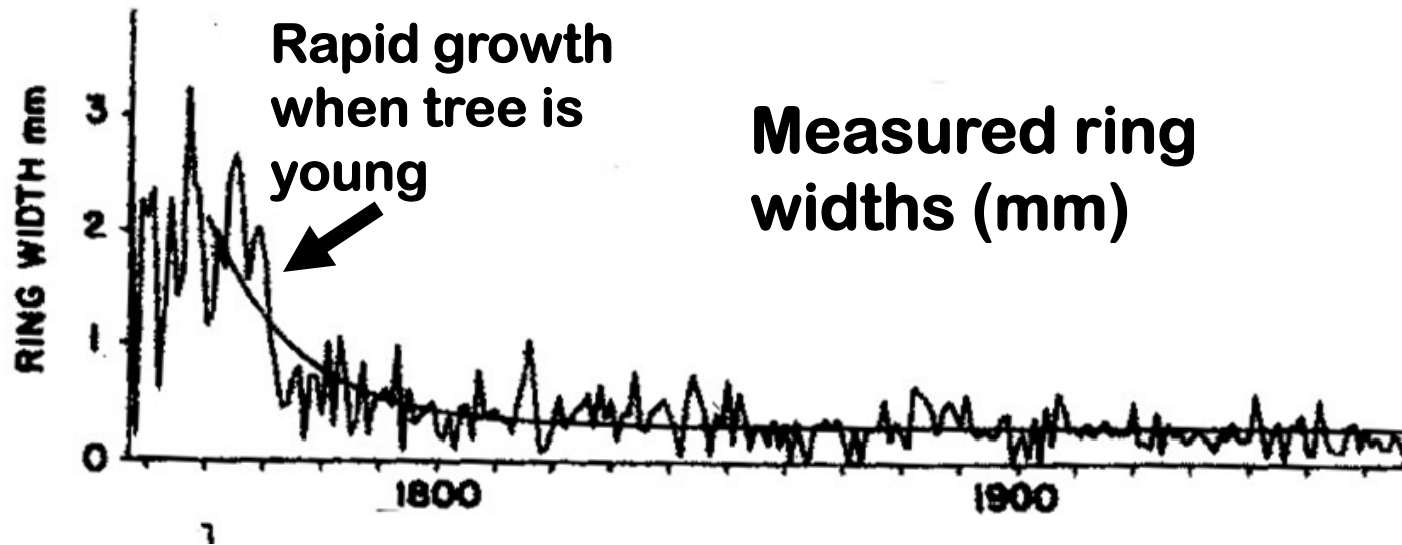
**Extract
cores with
an
increment
borer**



If the tree is already dead or cut down, we can take cross-sections from the tree or its stump →

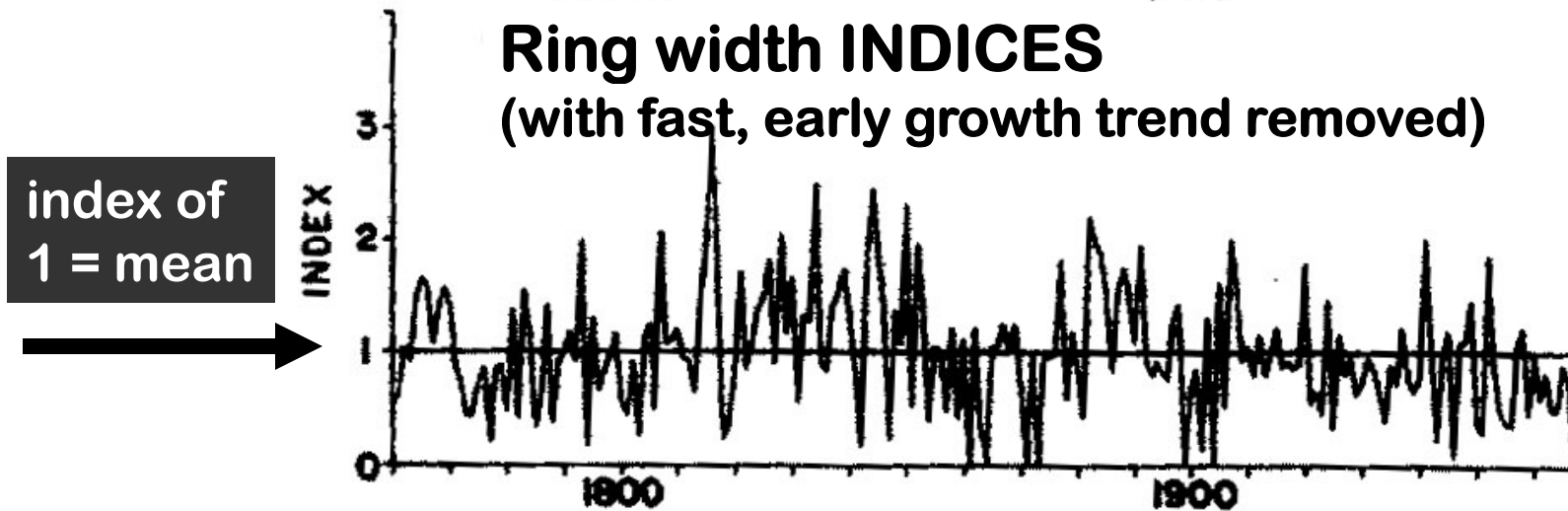
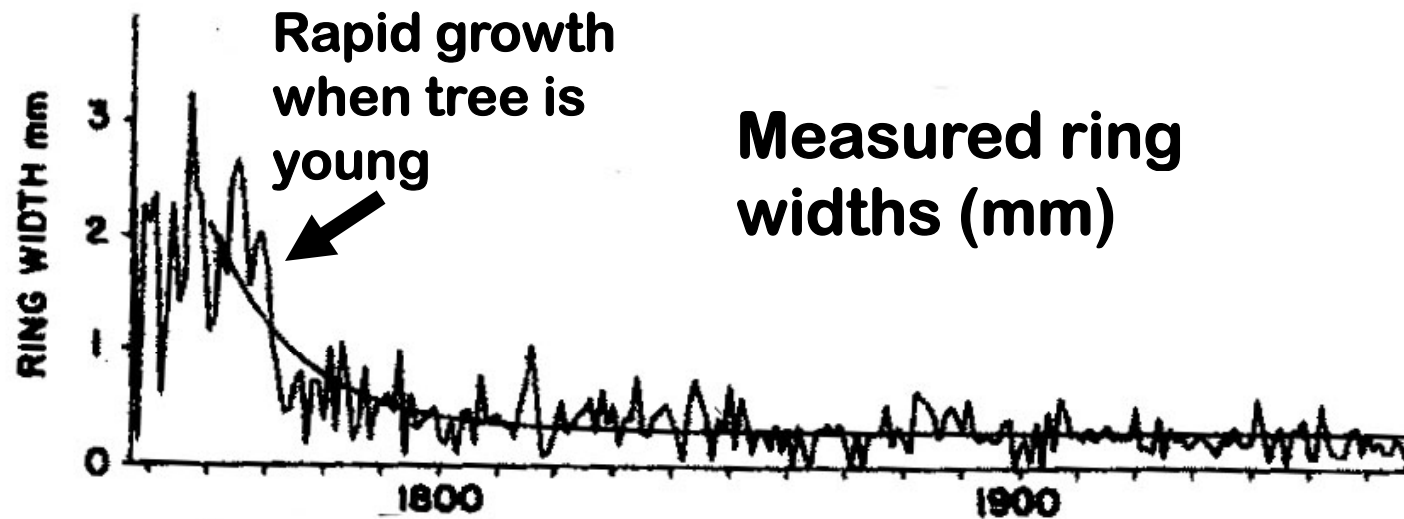
Notice how wide the rings in the center are – this was when the tree was young and growing faster!





TREE-RING WIDTH CHRONOLOGY

A time series plot!



TREE-RING WIDTH CHRONOLOGY

KEY PRINCIPLES OF DENDROCHRONOLOGY

UNIFORMITARIANISM –

**“The present is the key to the
past”**

**(this is a key principle for many other
natural archives as well)**

**Key
Principles
p 121**

LIMITING FACTORS –

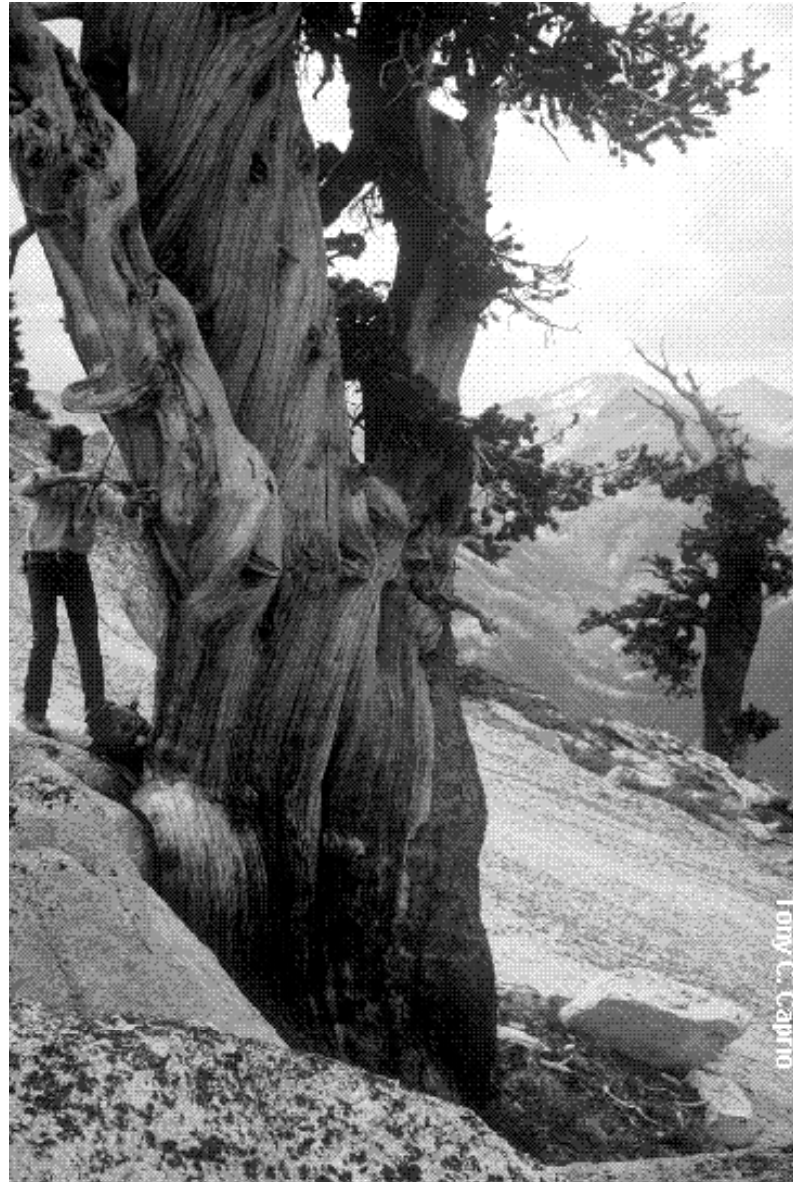
growth can occur only as fast as allowed by the factor that is most limiting, e.g.

- “too dry” – the amount rainfall is the limiting factor**
- “too cold” or “too hot” – the temperature is the limiting factor**
- NOTE: the limiting factor can vary from site to site, even in the same species of tree!**

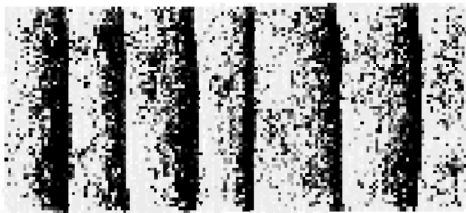
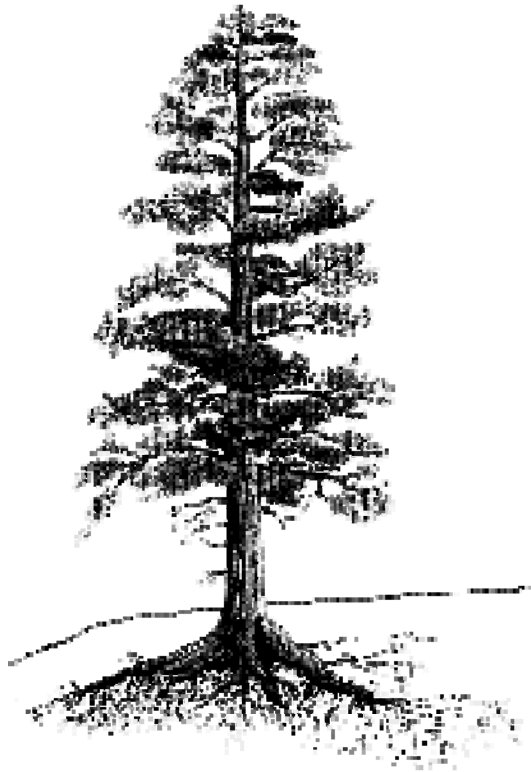
SITE SELECTION --

**sites are selected
based on criteria
of tree-ring
sensitivity to an
environmental
variable**

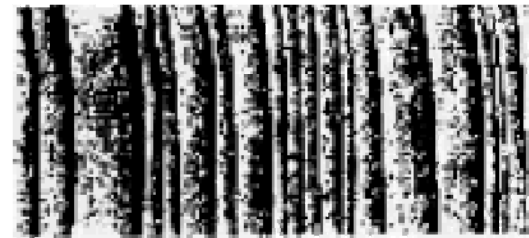
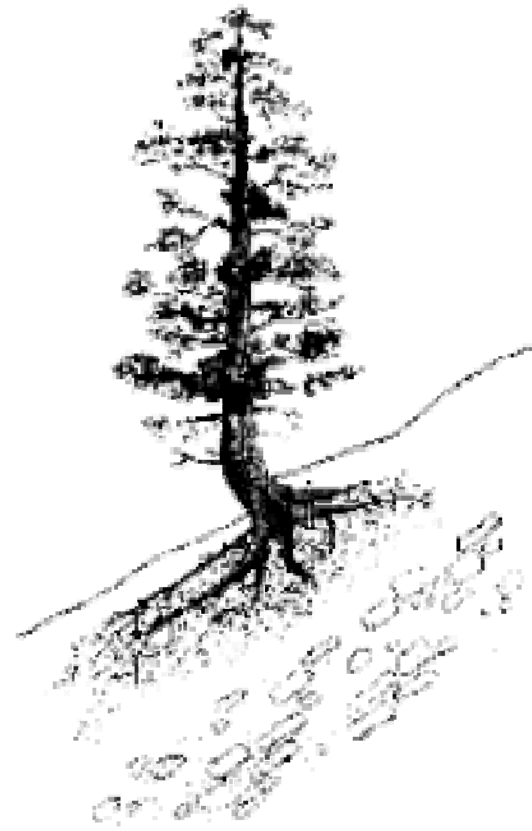
**(temperature,
precipitation, etc.)**



**Key
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Complacent



Sensitive

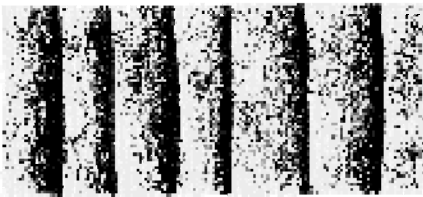
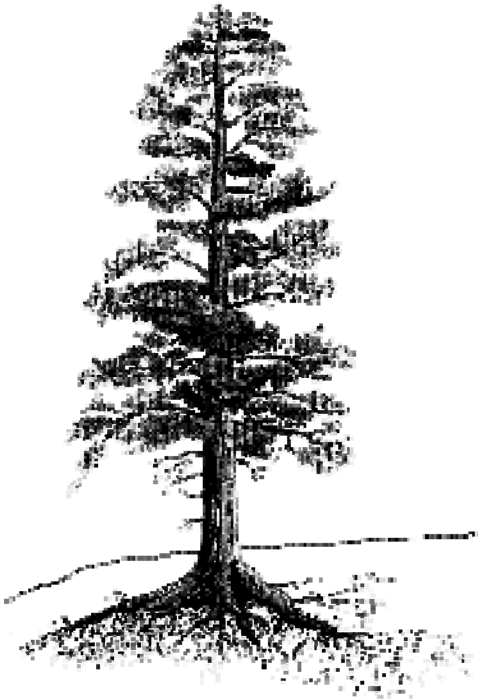
"Sensitive" tree growth:

- High degree of annual variation
- Wide and narrow rings intermixed through time
- Limiting growth factor (e.g., rainfall) is highly variable year to year
- Especially true for harsh sites (steep/rocky for moisture sensitivity; see figure at left)
- Reasonably sensitive ring growth is good:
 - Matching patterns of relatively wide and narrow rings across trees is easier when ample variation exists

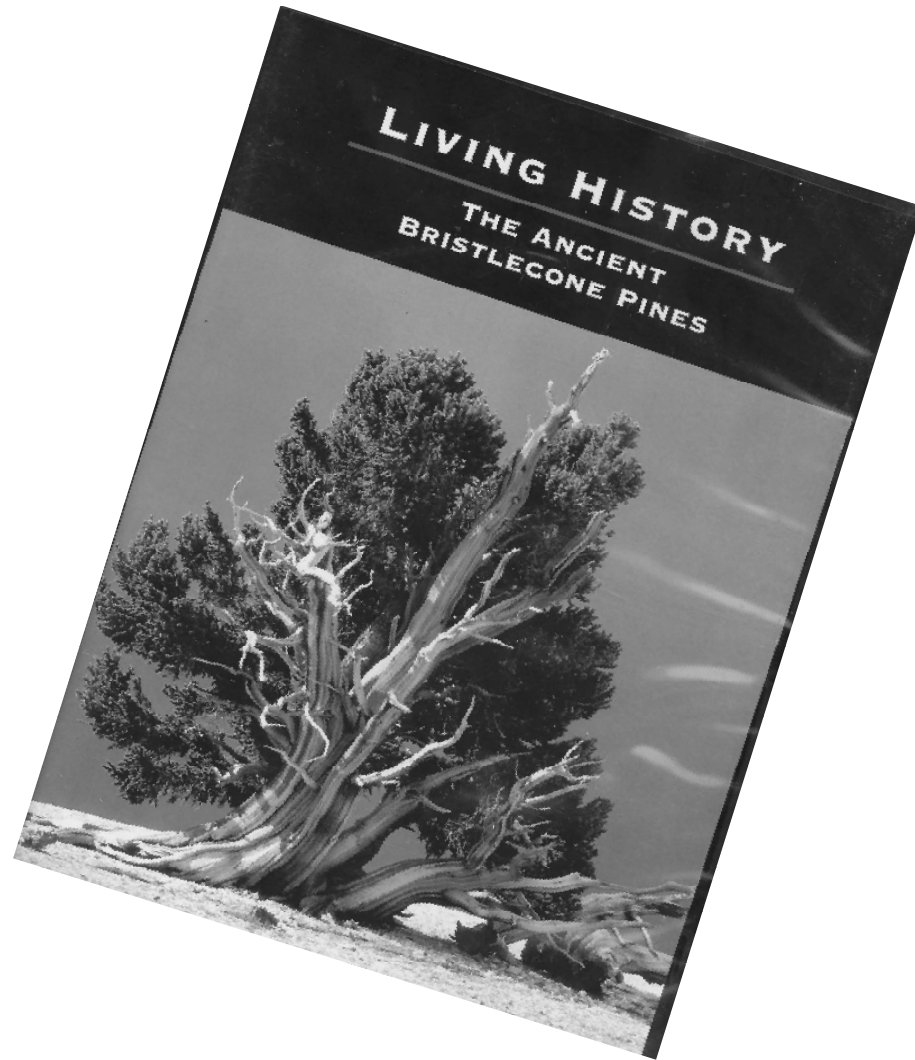


"Complacent" tree growth:

- Low degree of annual variation
- Rings are roughly the same for many years consecutively
- limiting growth factor is not variable from year to year
- Especially true for benign sites (flat with deep soil for moisture complacency; see figure at left)
- Complacent ring growth can be difficult to crossdate:
 - matching patterns of relatively wide and narrow rings across trees is harder when not much variation exists

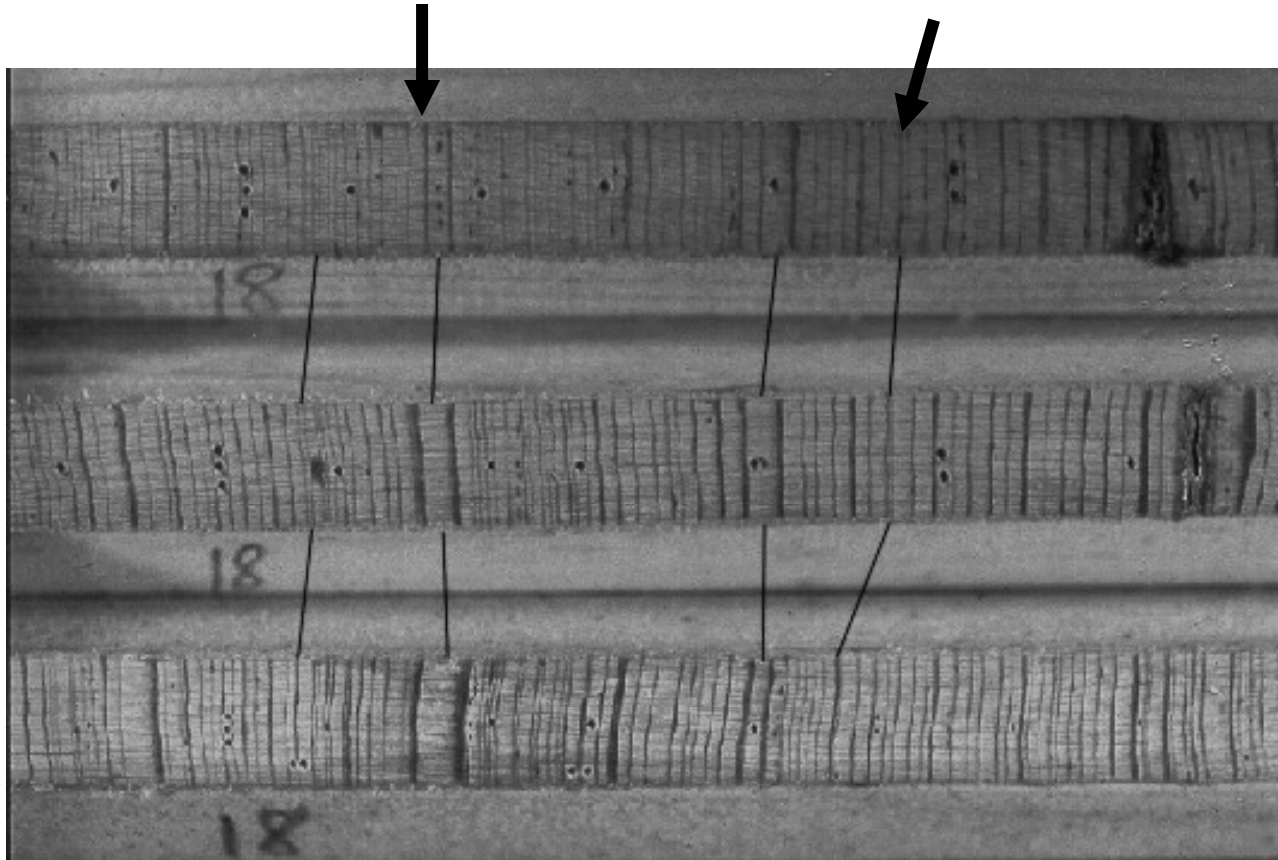


VIDEO BREAK:



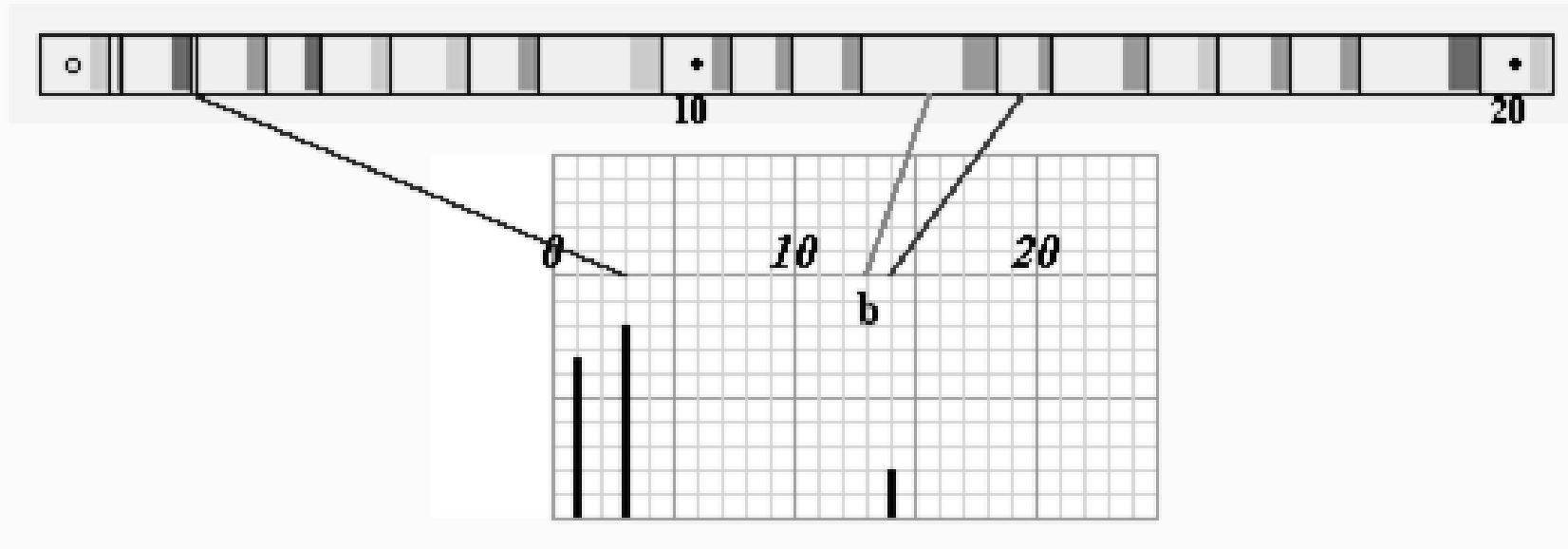
CROSSDATING –

matching patterns in rings of several tree-ring series will allow precise dating to exact year – HOW????



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MAKING SKELETON PLOTS OF A TREE-RING CORE



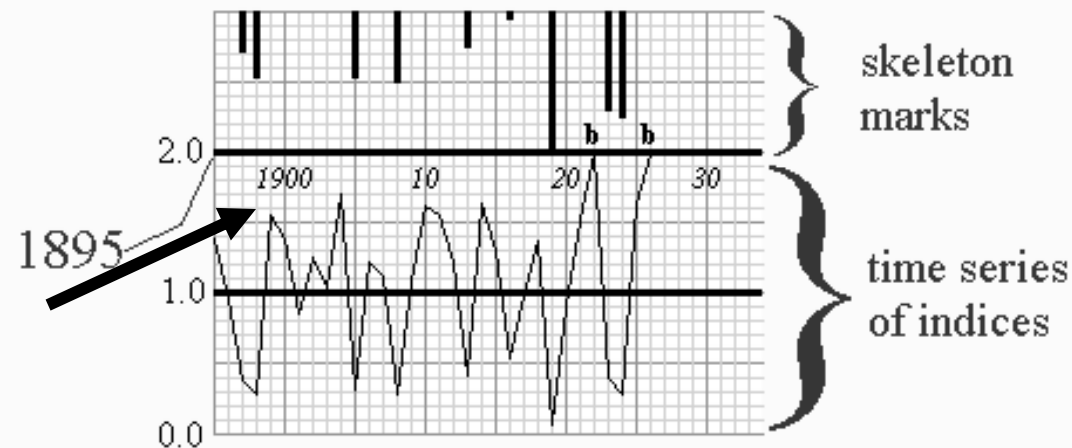
**You plot a line for each NARROW
ring, the narrower the ring,
the longer the line!**

<http://www.ltrr.arizona.edu/skeletonplot/plotting.htm>

DATED MASTER CHRONOLOGY

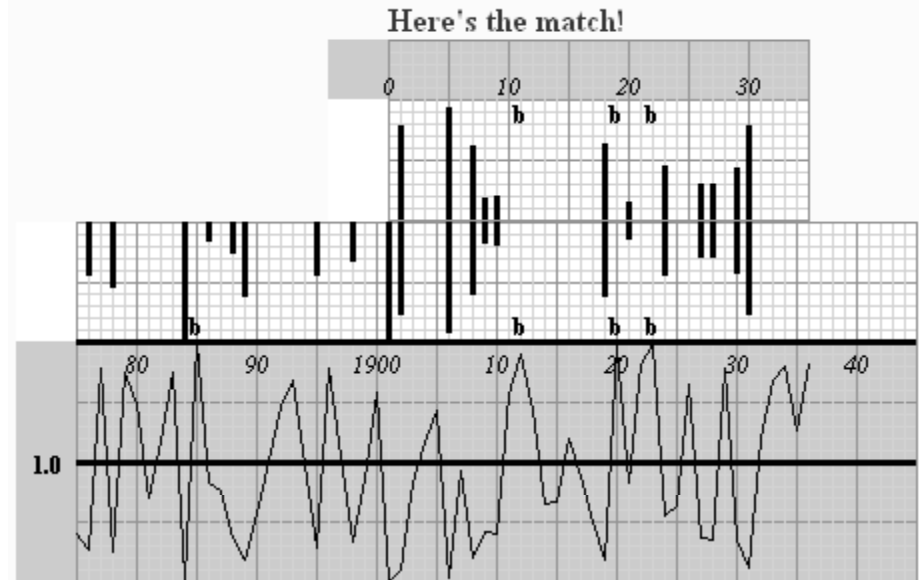
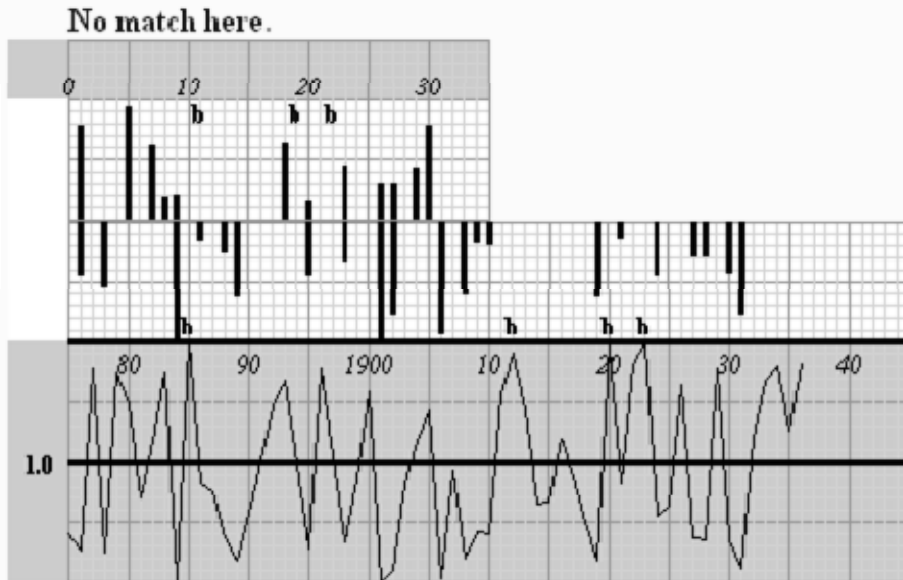
The master chronology is based on previously measured and dated tree rings from the same area

**Actual
calendar
dates**



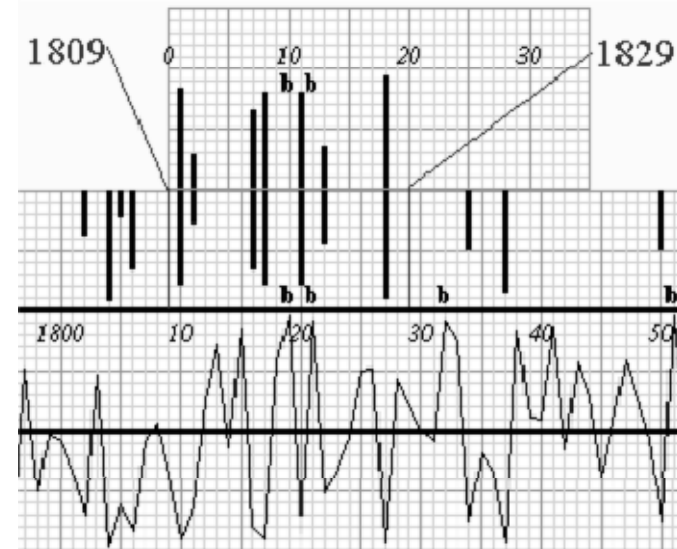
PATTERN MATCHING

You match the pattern of the skeleton plot from the undated core with the skeleton plot of the dated master chronology:



<http://www.ltrr.arizona.edu/skeletonplot/patternmatching.htm>

After the pattern matches with the **MASTER CHRONOLOGY**, you can **ASSIGN ACTUAL CALENDAR DATES** to the skeleton plot & core



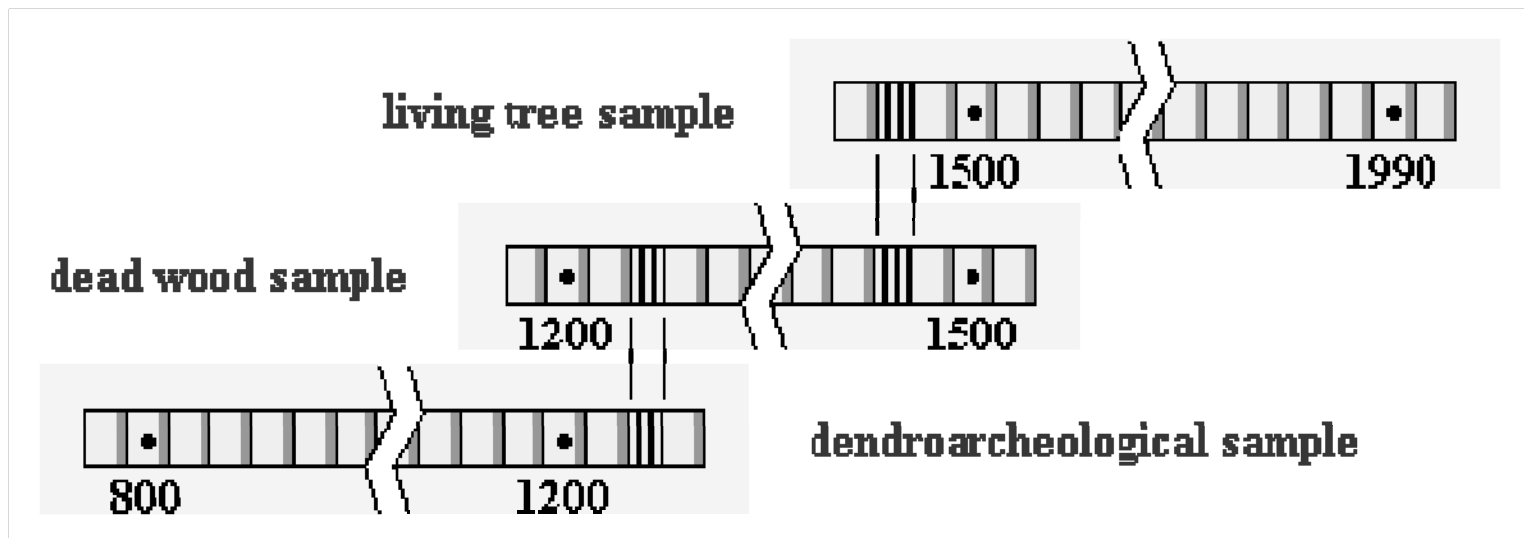
All of these are part of the answer:
Start year: 1809
Absent rings:
False rings:
End year: 1829

This is CROSSDATING!

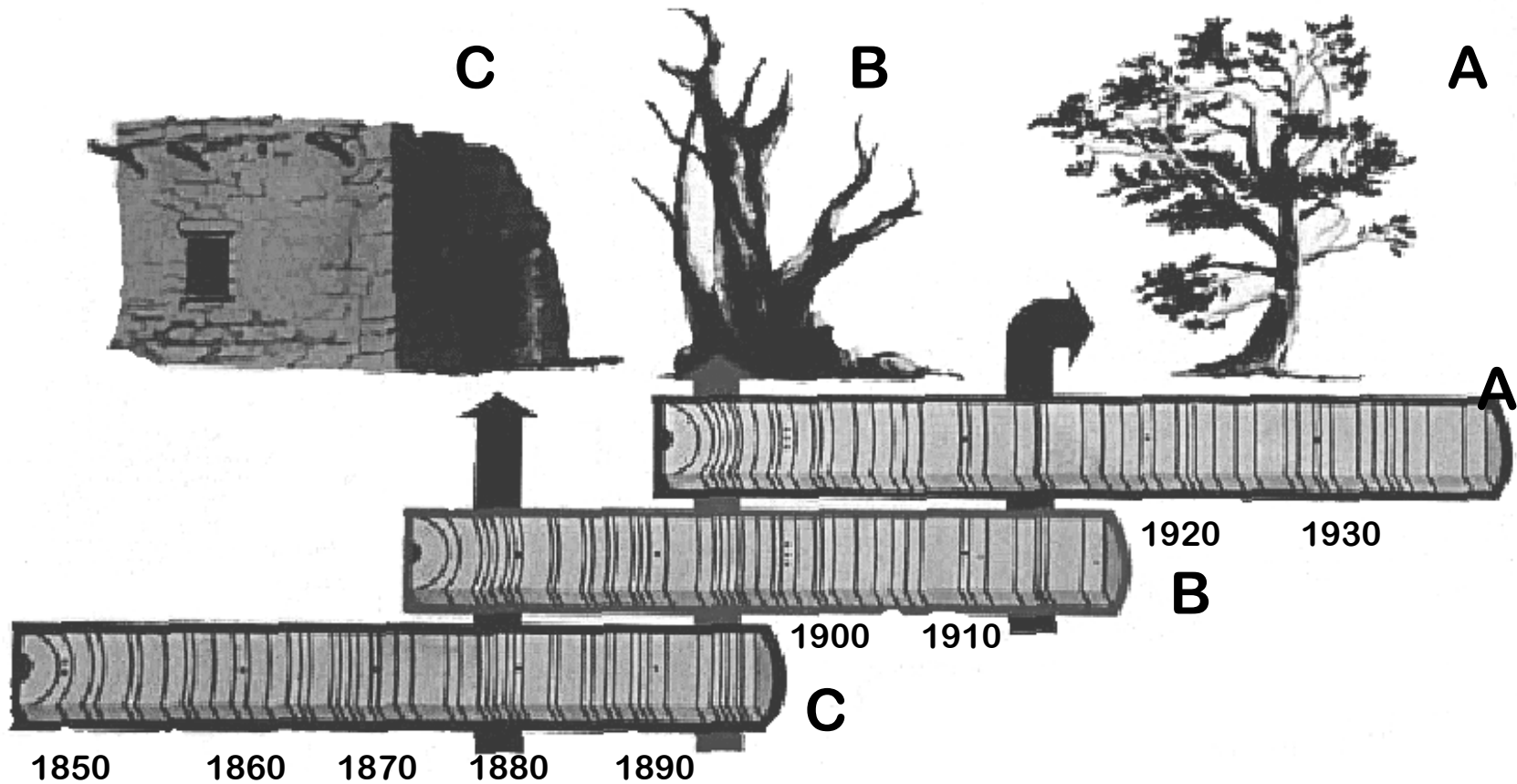


After crossdating, dendrochronologists can:

- Assign the true year of formation for every ring of each sample
- Analyze past environmental and/or human events.
- Overlap crossdated samples, as shown to extend the record back in time:



Crossdating: The Basic Principle of Dendrochronology

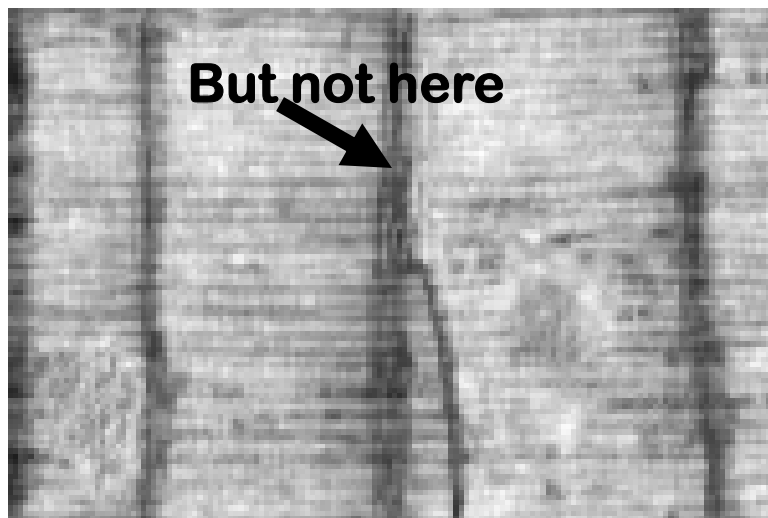


<<<<<<<< “Bridging” the record back in time <<<<<<<<



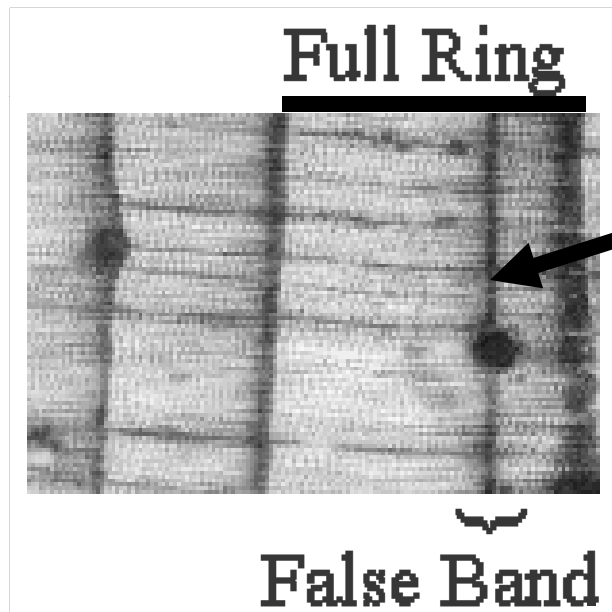
Two Crossdating Challenges:

MISSING RINGS (“locally absent” rings)



Two Crossdating Challenges:

“FALSE” RINGS



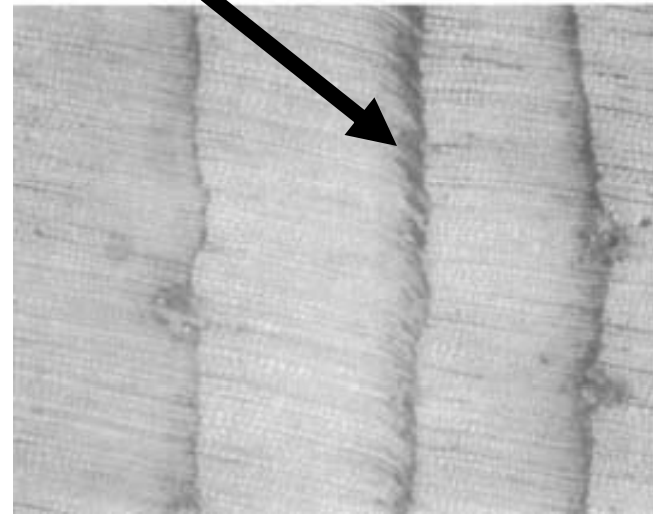
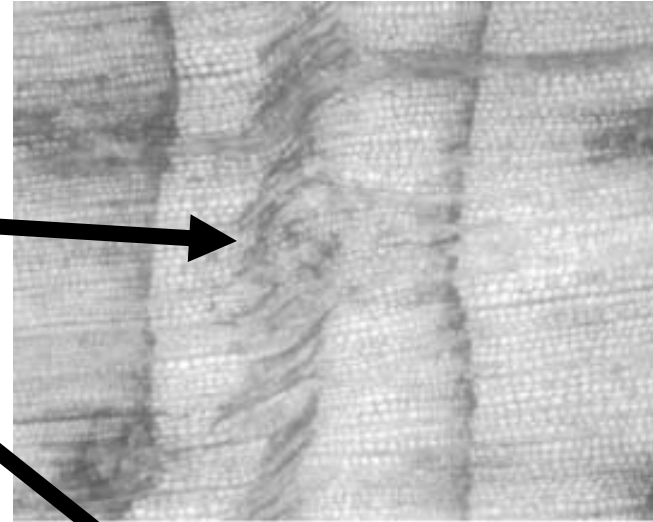
During stressful time during growing season, tree begins to shut down growth, then growth resumes – so looks like two annual rings, when all the growth occurred during the same year!



One more type of ring, that is a very useful crossdating aid:

“Frost Rings”

Growing cells get crushed and damaged during an unseasonable FREEZE event (1 -2 days) of below freezing temperatures → leaves permanent mark in the wood!
AIDS PATTERN MATCHING!



Now, back to the principles:

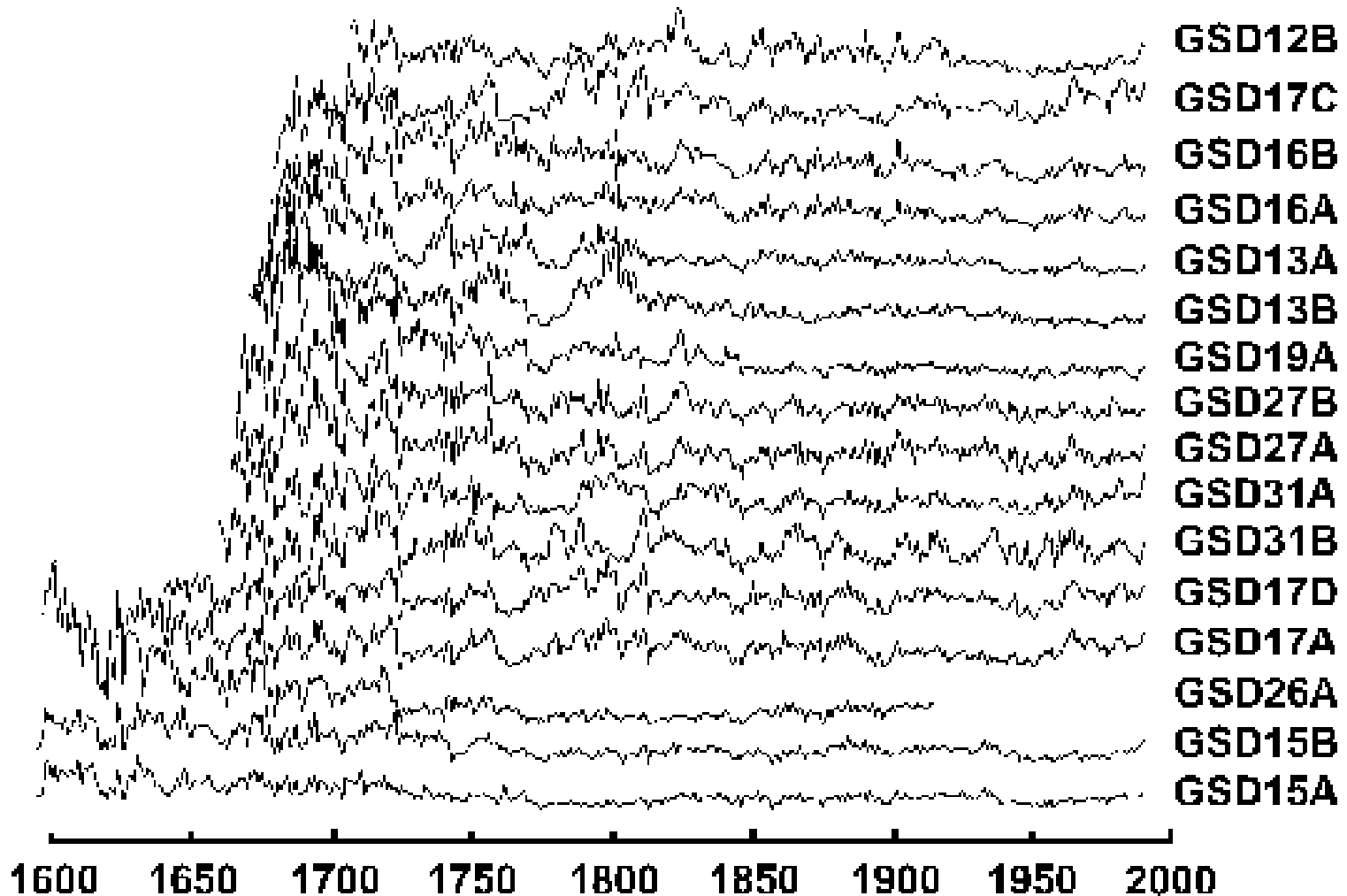
REPLICATION –

“noise” minimized by sampling many trees at a site + more than one core per tree



**Key
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Great Sand Dunes

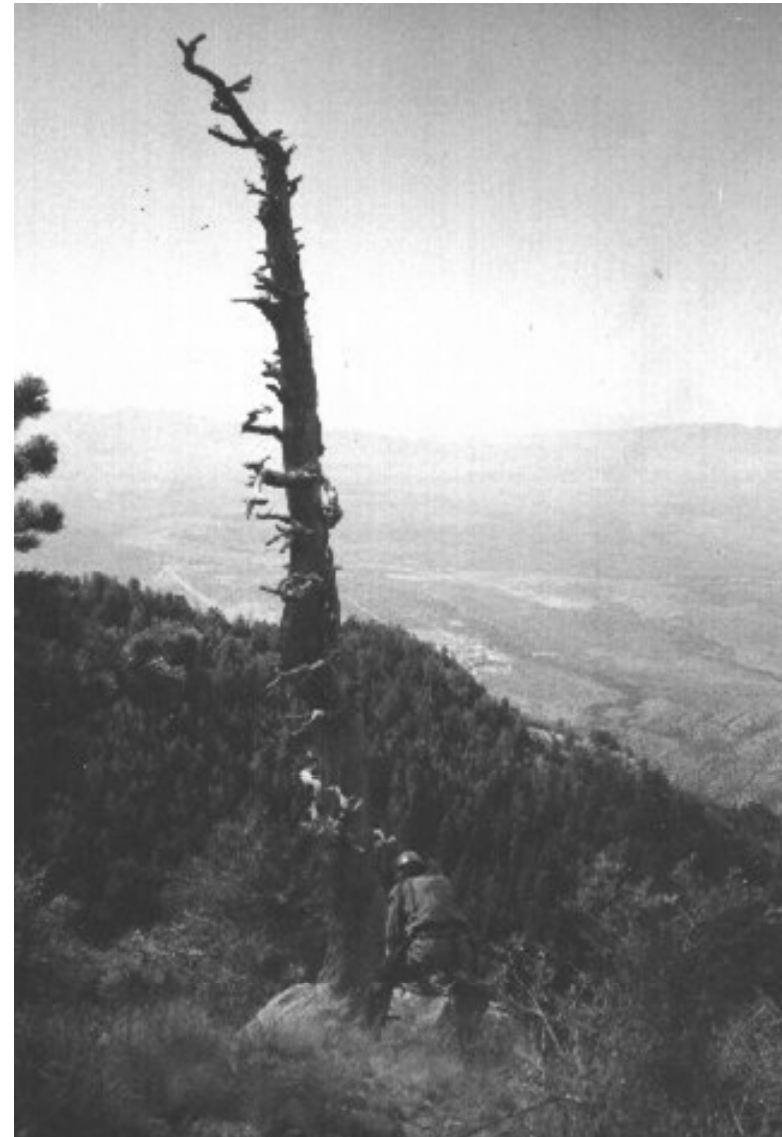


ECOLOGICAL AMPLITUDE –

**trees are more
sensitive to their
environment at
latitudinal and
elevational limits
of the tree
species' range**

**Very old tree on Mt Graham,
SE Arizona**

inner ring date: A.D. 1101



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KEY SCIENTIFIC ISSUES

- **Missing rings & false rings (to identify these, need a “master chronology”)**

• **Species limitations (some trees have no rings, non-annual rings, or poorly defined rings)**

• **Trees must crossdate! (can't develop a chronology or link to climate without this)**

↑
Today's class activity

Top of
p 122

- **Geographical limitations
tropics, deserts and other
treeless areas, oceans, etc.)**



- **Age limitations**
(old trees hard to find; oldest living trees = Bristlecone Pines
> 4,000 years old: 4,780+)



- **Value of precise dating**
(long chronologies, climate reconstructions, archaeology, radiocarbon dating)



I-2 ASSIGNMENT TREE-RING CROSSDATING DEMO

ASSIGNMENT I-2 LINK:

http://fp.arizona.edu/khirschboeck/nats101gc/i-1_skeleton.htm

CROSSDATING TUTORIAL LINK:

<http://www.ltrr.arizona.edu/skeletonplot/introcrossdate.htm>

MAKING YOUR OWN SKELETON PLOT ONLINE FOR I-2

<http://www.ltrr.arizona.edu/skeletonplot/SkeletonPlot19.htm>

See p 126 – 127 and D2L ASSIGNMENT I-2

**ASSIGNMENT 1-2 on
Tree-Ring Crossdating will be
DUE THURSDAY OCT 1
(in the D2L Dropbox)**

**HELP SESSIONS
to be held next week”**

Monday Sep 28 between 4:00 - 5:00
Wednesday Sep 30 between 1:30 - 3:00 pm
Wednesday Sep 30 between 5:30 - 6:30 pm

in SCIENCE LIBRARY 308