Global Change Tools

TREE RINGS & NATURAL ARCHIVES

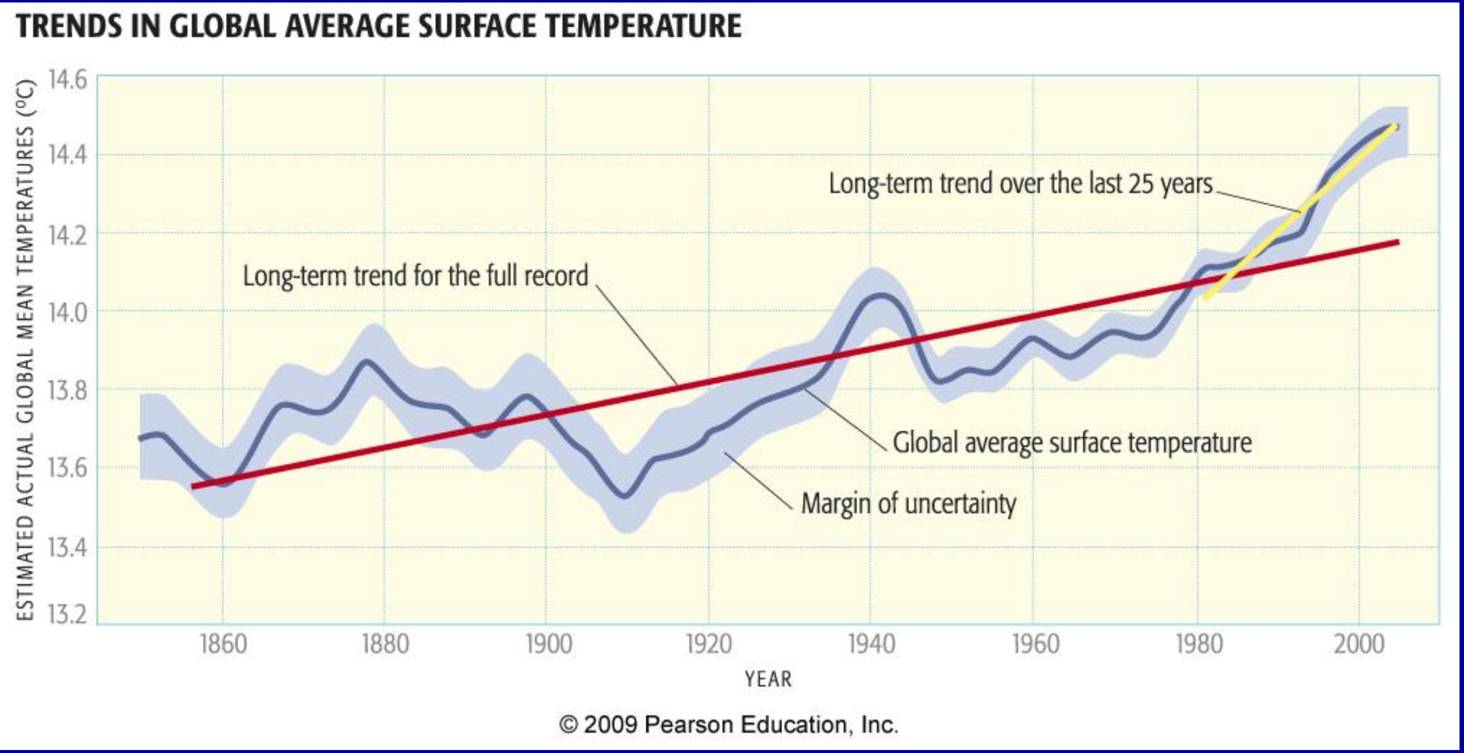
Trees and stones will teach you that which you can never learn from masters.

~ St. Bernard of Clairvaux

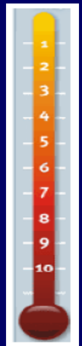
DETECTING GLOBAL WARMING:

In the recent past, we use the "INSTRUMENTAL RECORD" based on actual <u>Thermometer</u> readings from around the globe

Temperature Trends →



From **Dire Predictions, p 36**



We looked at some of these during this Indicator Interlude . . . **Remember these time series “anomaly” plots?**

INDICATOR INTERLUDE . . .

But what about what happened long before the Industrial Revolution?

Don’t we really need to look at temperatures from a LONG time ago to assess the severity of the recent temperature observations of warming?

These temperature records and graphs are available online at the National Climatic Data Center (NCDC) of NOAA (The National Oceanic & Atmospheric Administration): http://www.ncdc.noaa.gov/cmb-faq/anomalies.php

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

1) a long-term temperature record, i.e., centuries
2) over a large part of the globe
3) To be able to say . . . . .

"What's the average been for several hundred years, & is this a significant departure from that?"

"And that's very difficult to do."

(James Trefil, physicist)

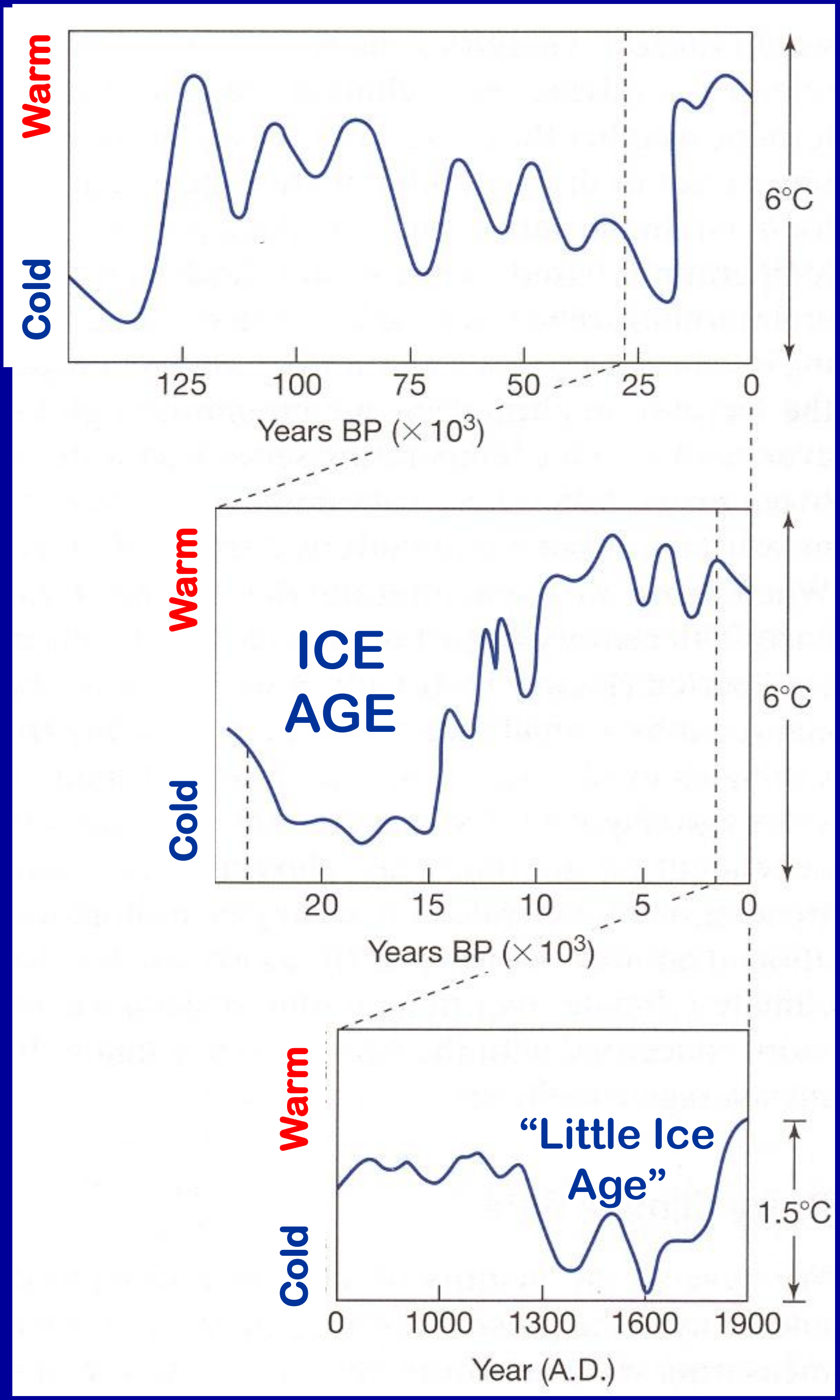
Review: p 17

NATURAL ARCHIVES CAN GIVE US INSIGHTS INTO THE PAST . . . .

. . . over different "Telescoping" Time Scales Of Variability about:

Mean Global Temperature Change

Since The Last Glacial Maximum
(Years BP = "years before present")



Generalized oxygen isotope curve from **deep-sea sediments**

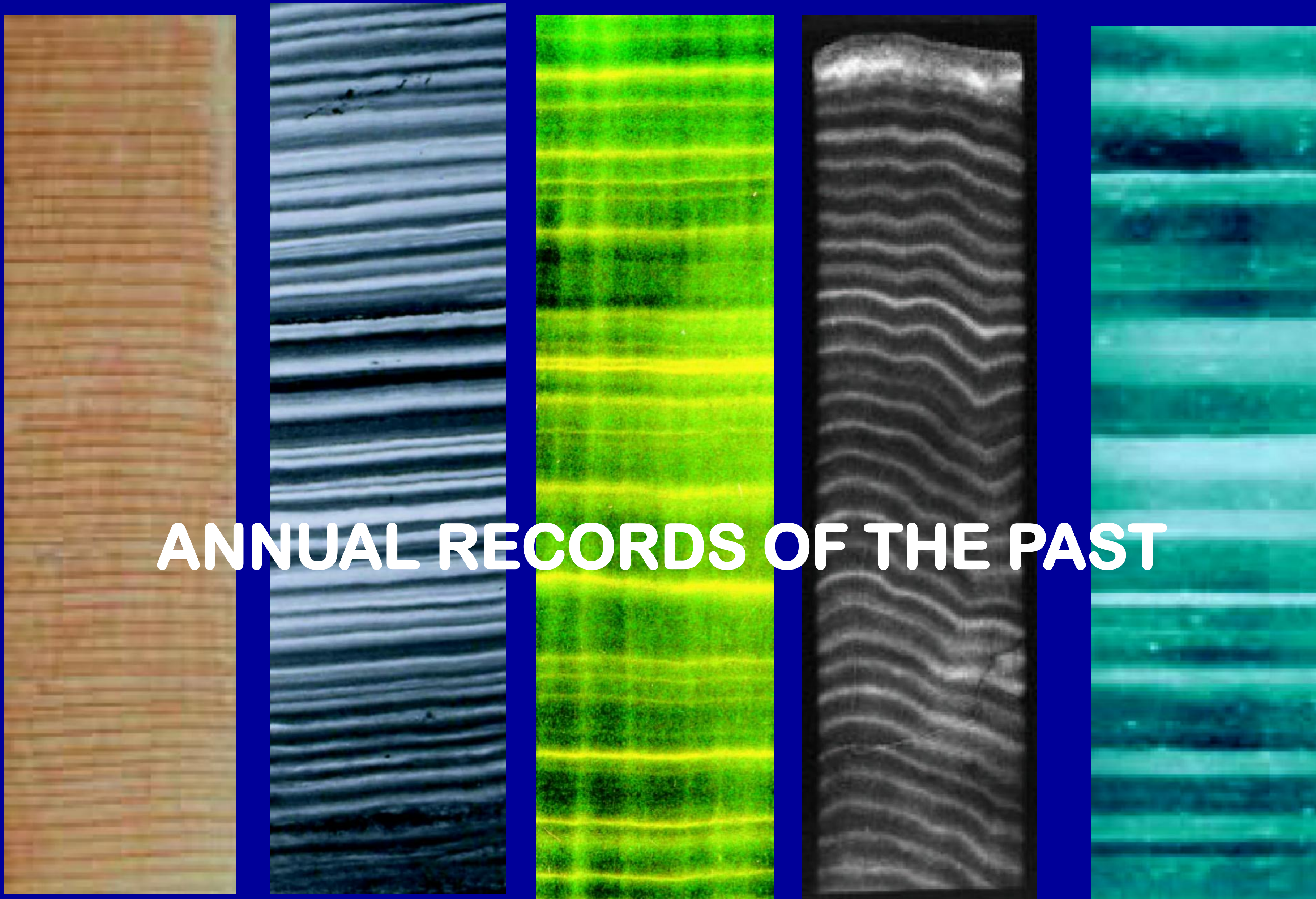
Generalized estimates from **pollen data & alpine glaciers** (mid-latitudes of eastern N. America & Europe)

General estimates from **historical documents** (emphasis on the North Atlantic region)

review p 17

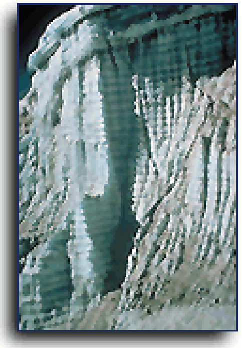
ANNUAL RECORDS OF THE PAST

Tree rings | Lake varves (sediments) | Speleothems (from cave) | Coral (annual growth) | Ice Core



“PROXY” DATA or NATURAL ARCHIVES of CLIMATE

Corals



Ice cores

Pollen

Lake, bog & ocean sediments

INTRODUCTION TO TREE RINGS & DENDROCHRONOLOGY

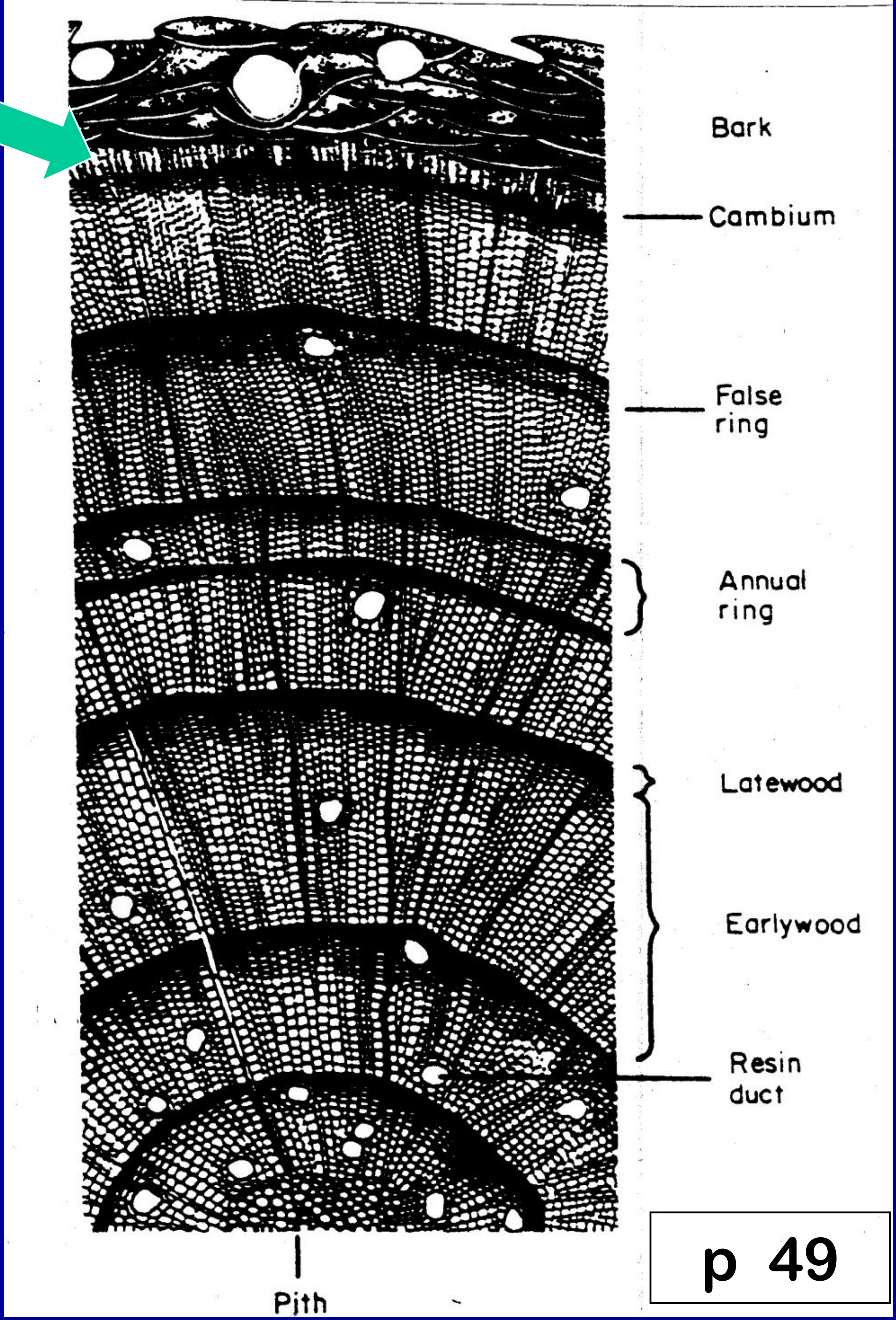
Topic #9 in CLASS NOTES
p 49-51

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 . . .

The current year's actively growing cells are just underneath the bark

Partial cross-section of a coniferous tree



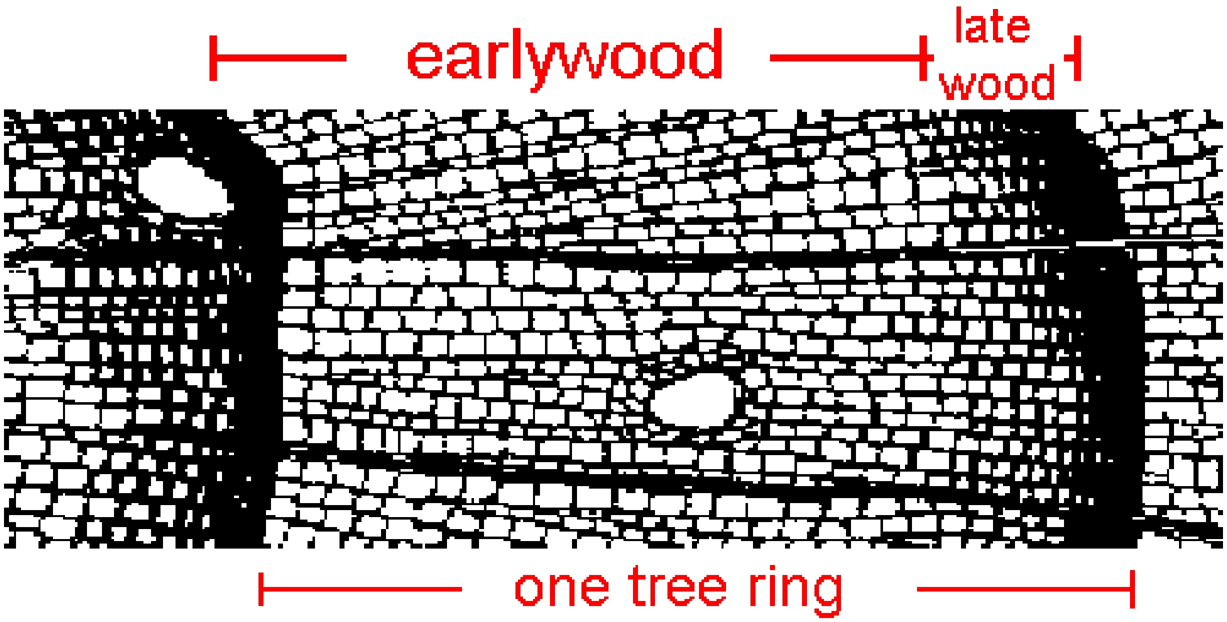
How old is it? (in complete years) count 'em!

7 years old

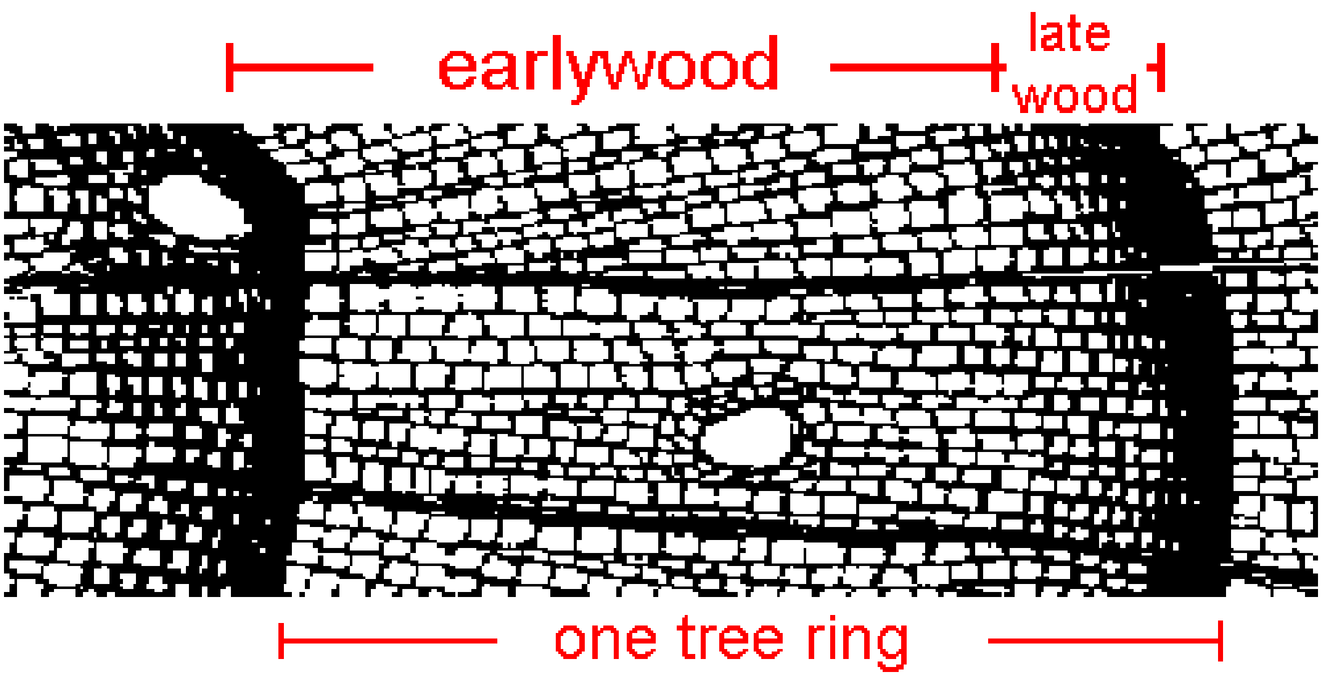
(now in 8th year of growth)

Why we can see the rings: cell size & thickness changes during the growing season

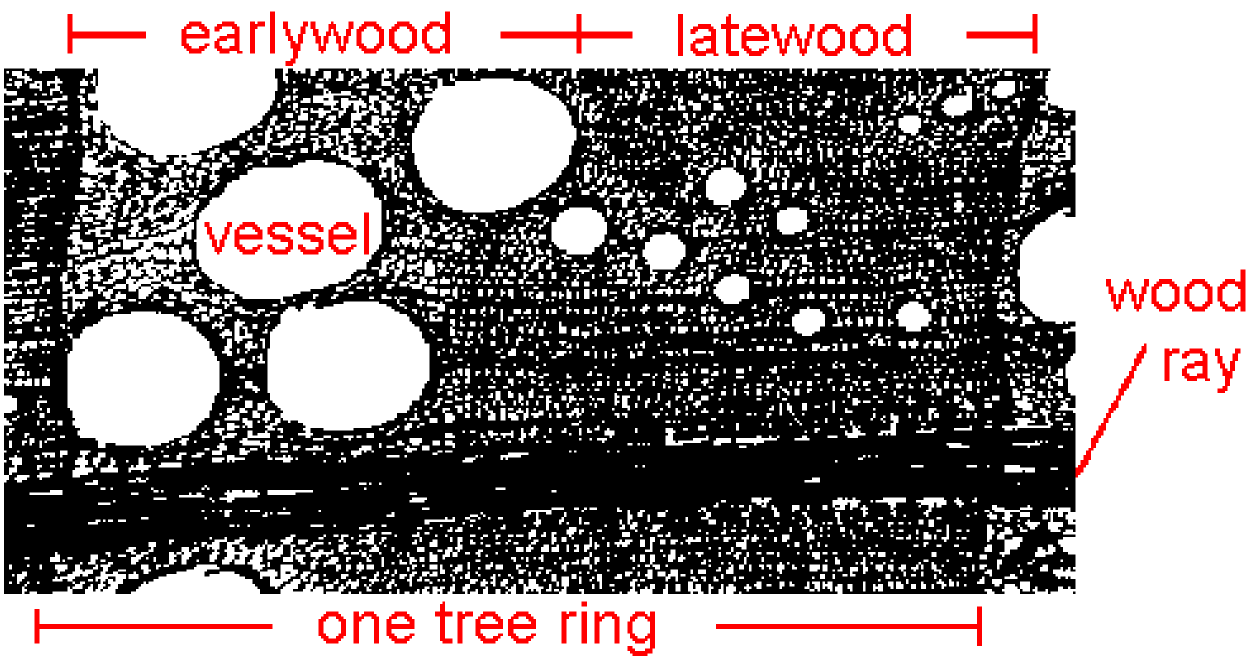
Conifer Tree Ring (cross-section view)



- 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)

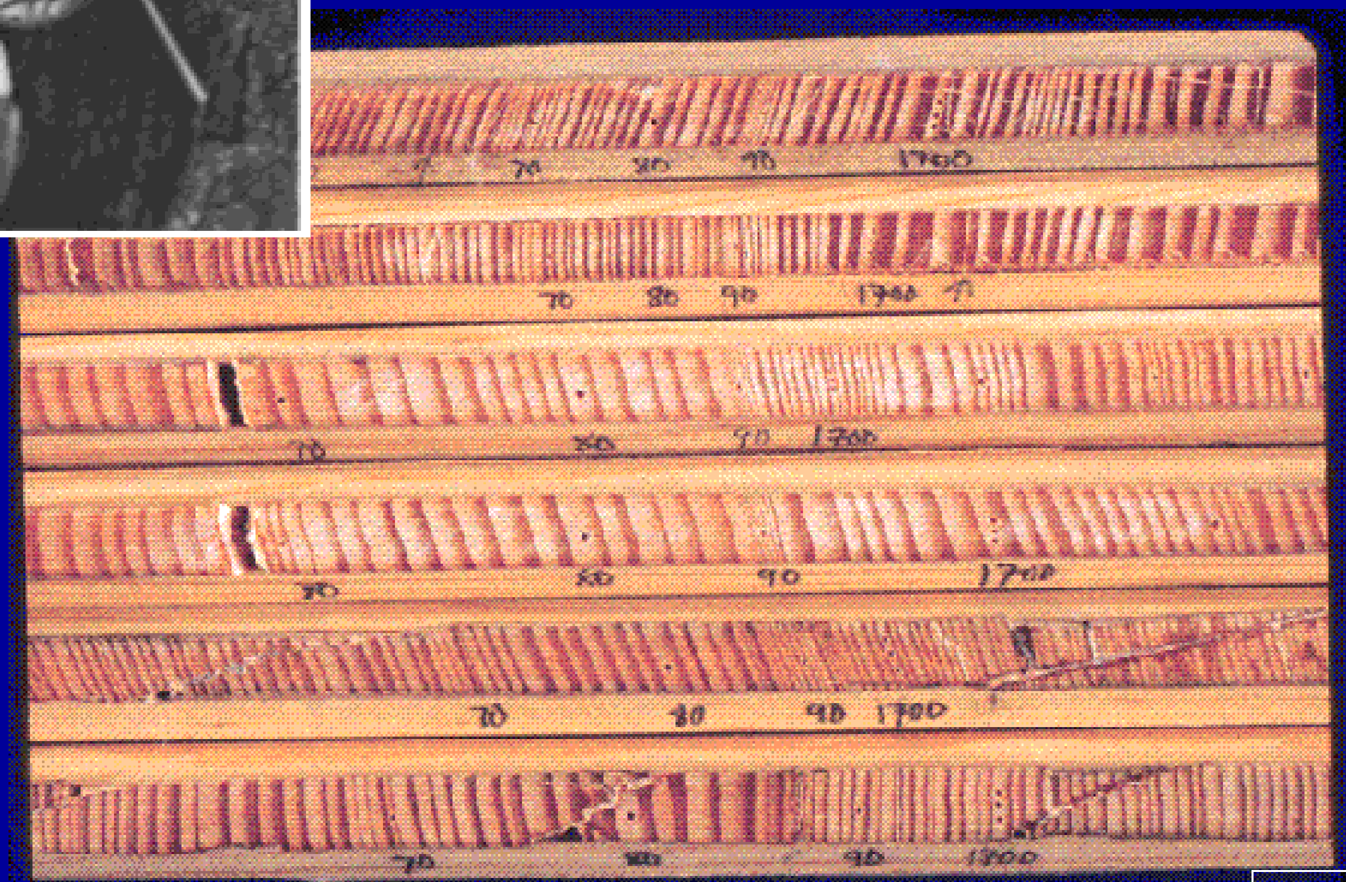
☺

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)

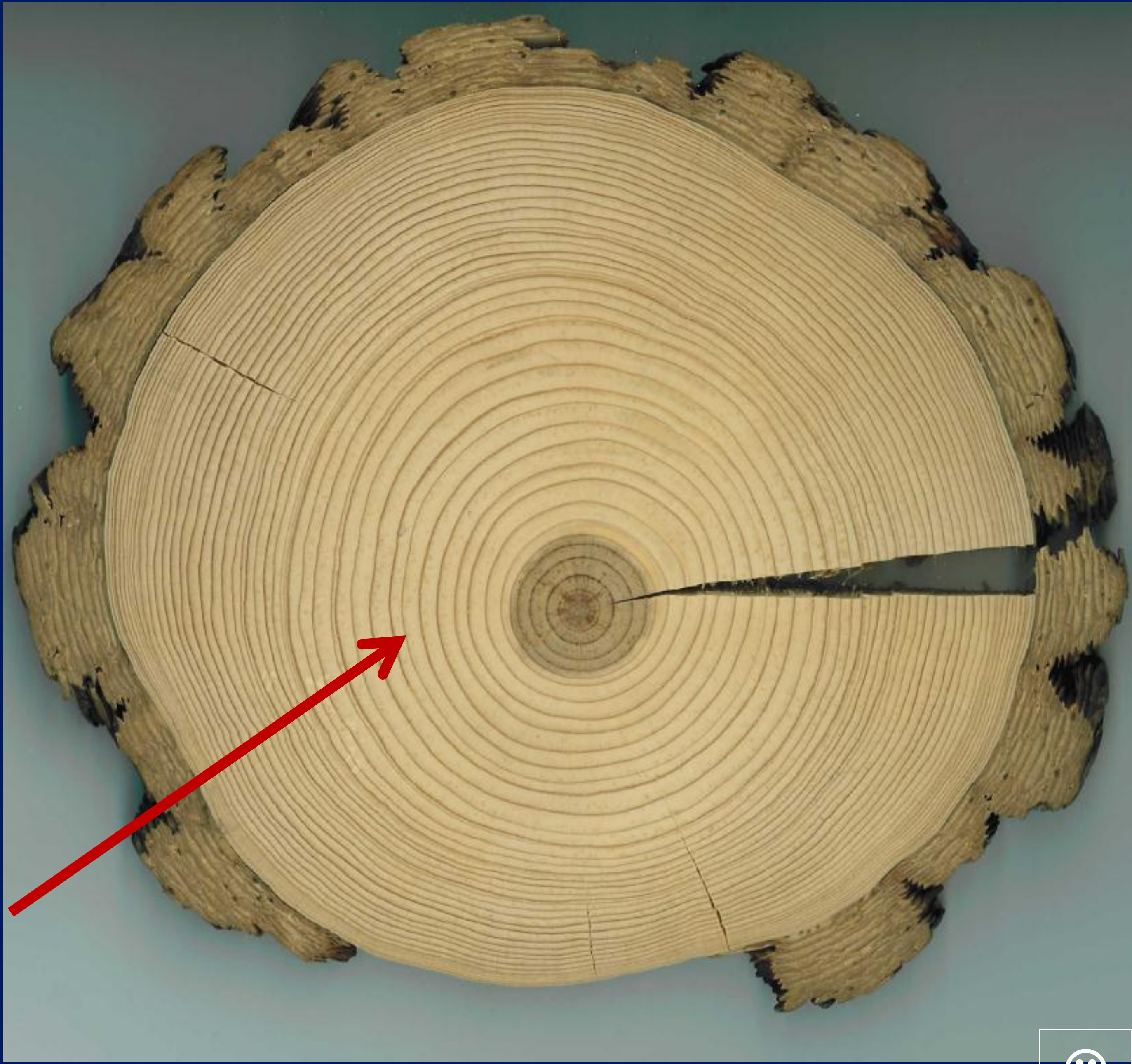
Thus, studying this variation leads to improved understanding of past environmental conditions and is the basis for many research applications of dendrochronology.

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

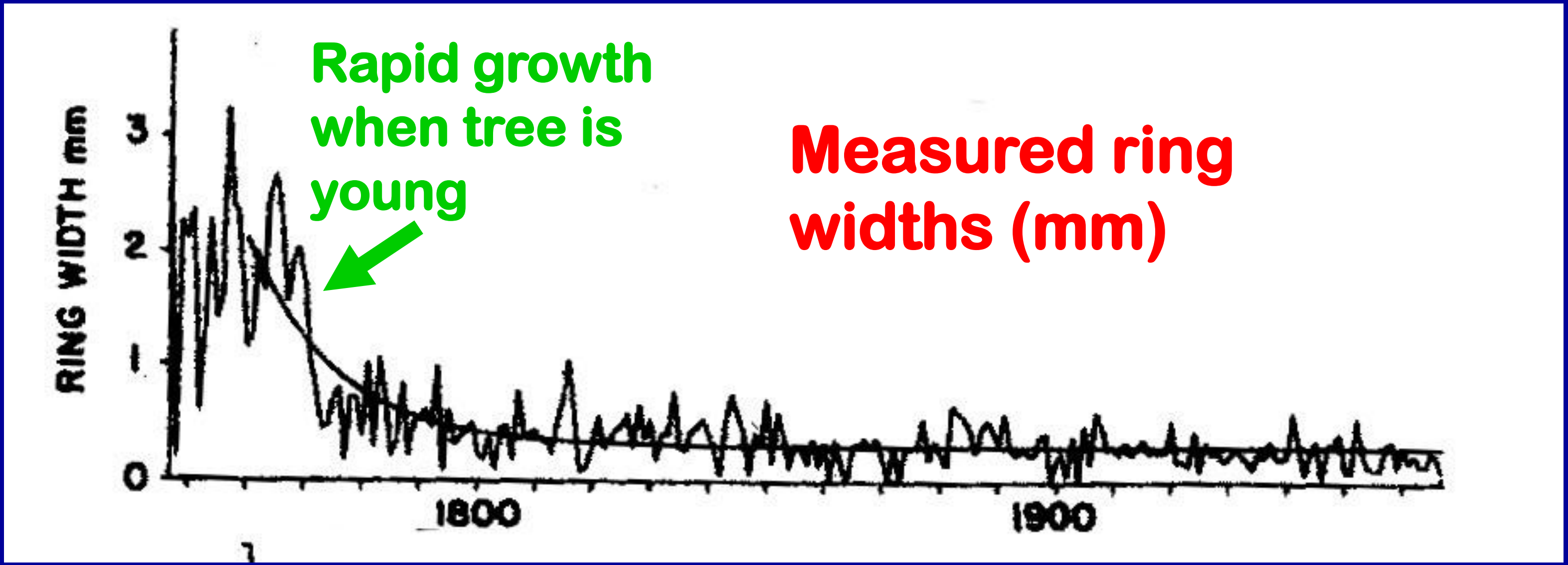


Extract cores with an increment borer

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

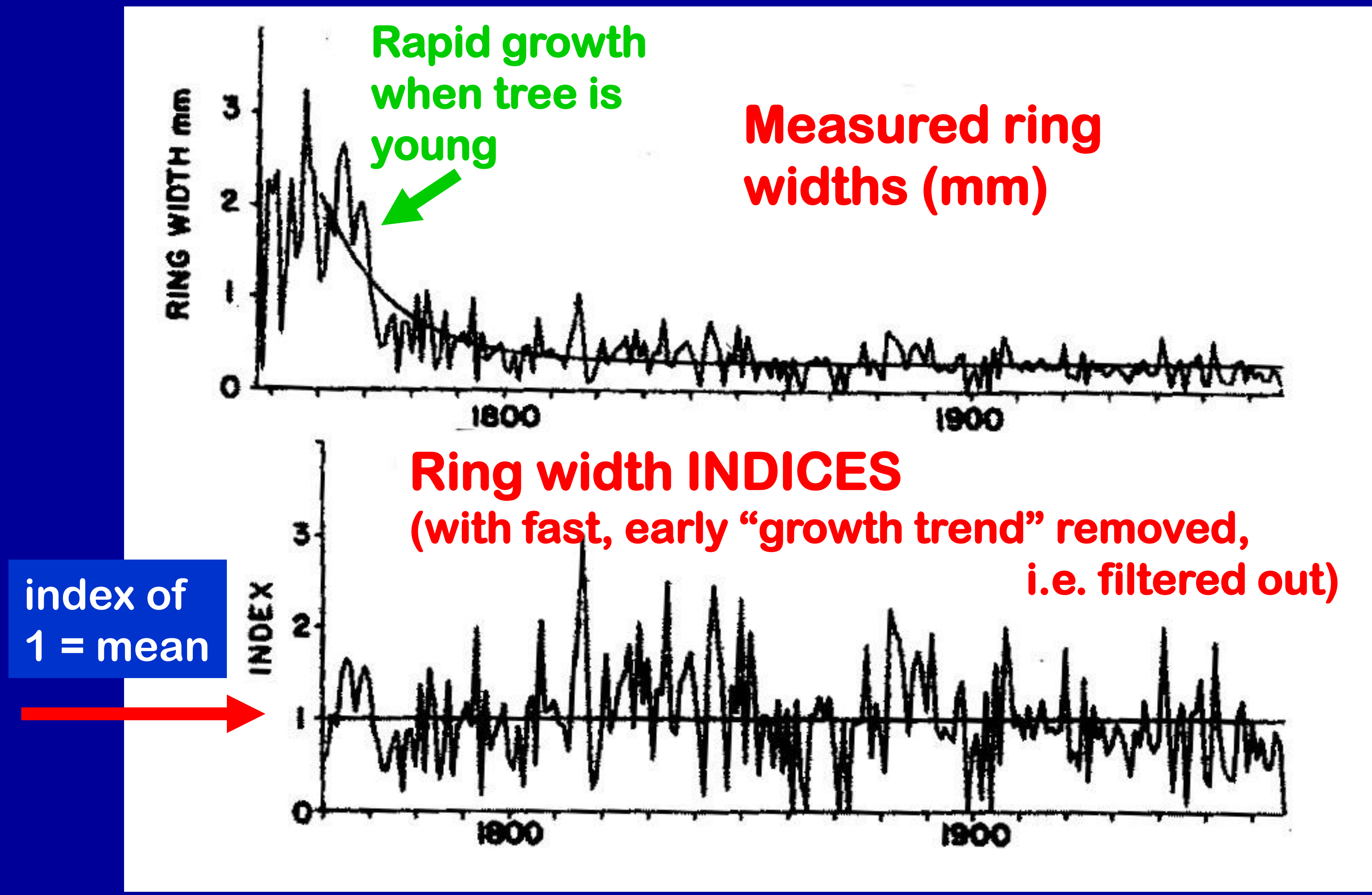


Notice how wide the rings in the center are – this was when the tree was young and growing faster!



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 used in the geological sciences as well)

Key Principles p 49

LIMITING FACTORS –

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

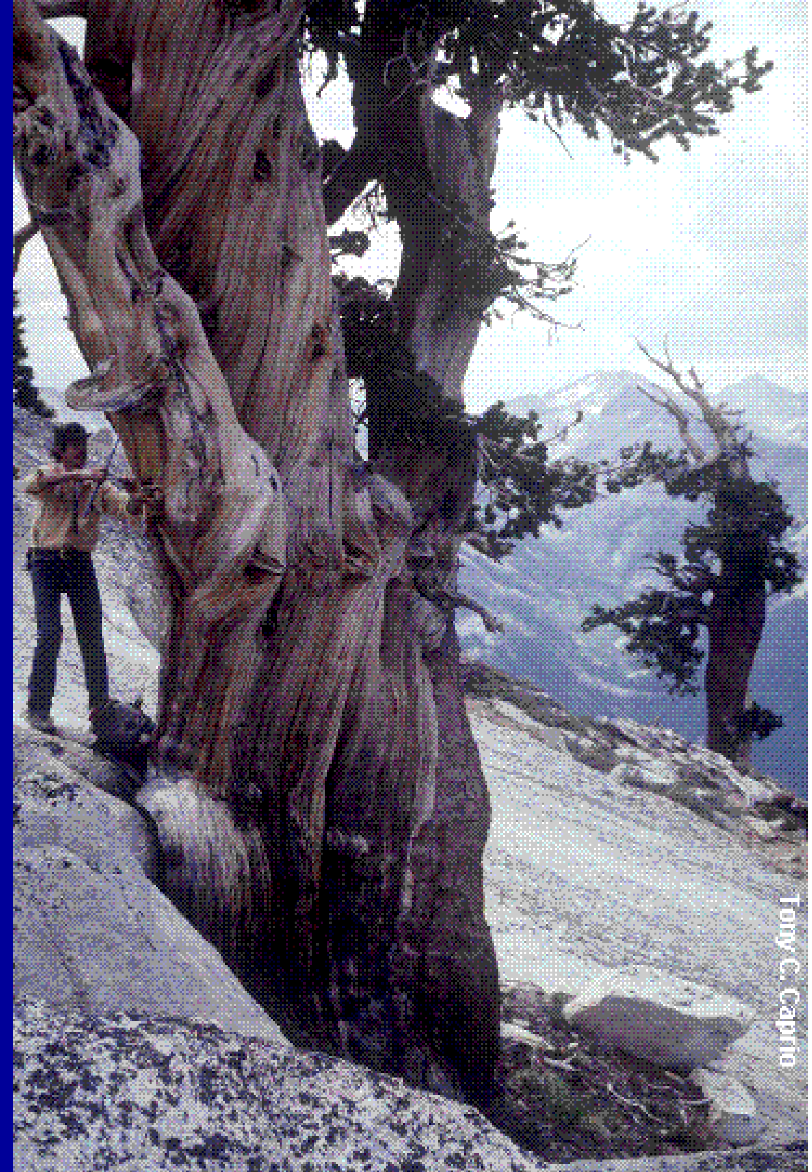
- "too dry" – the amount rainfall is the limiting factor
- "too cold" or "too hot" – the temperature is the limiting factor
- NOTE: the limiting factor can vary from site to site, even in the same species of tree!

Key Principles p 49

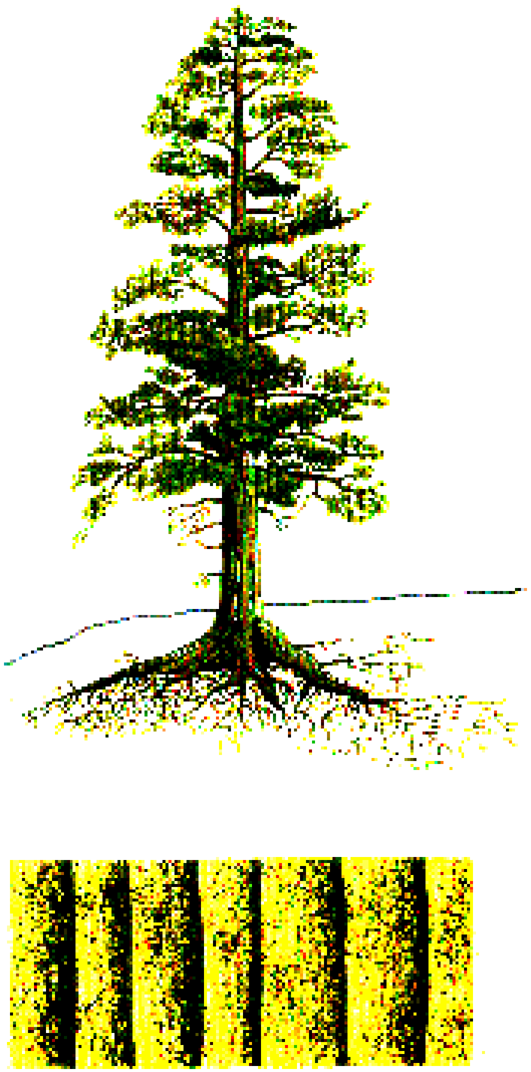
SITE SELECTION --

sites are selected based on criteria of tree-ring <u>sensitivity</u> to an environmental variable

(temperature, precipitation, etc.)

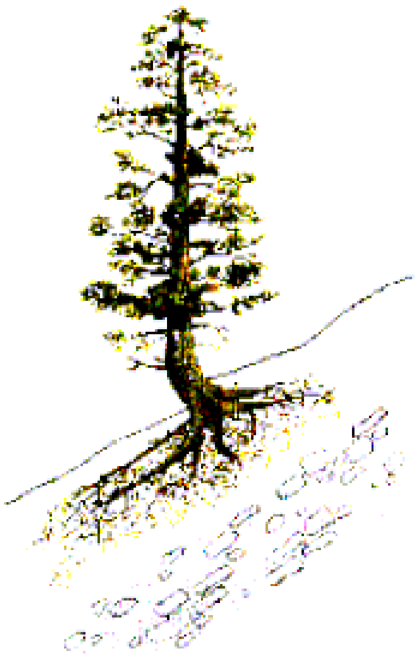


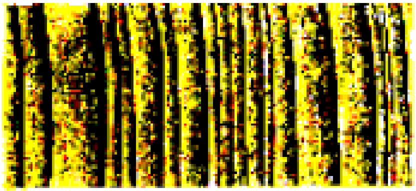
Key Principles p 49



Complacent

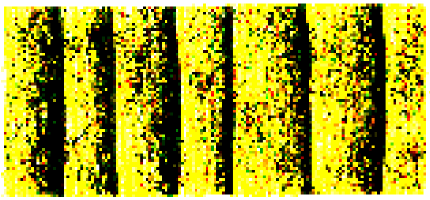
Sensitive





"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 narrows rings across trees is easier when ample variation exists

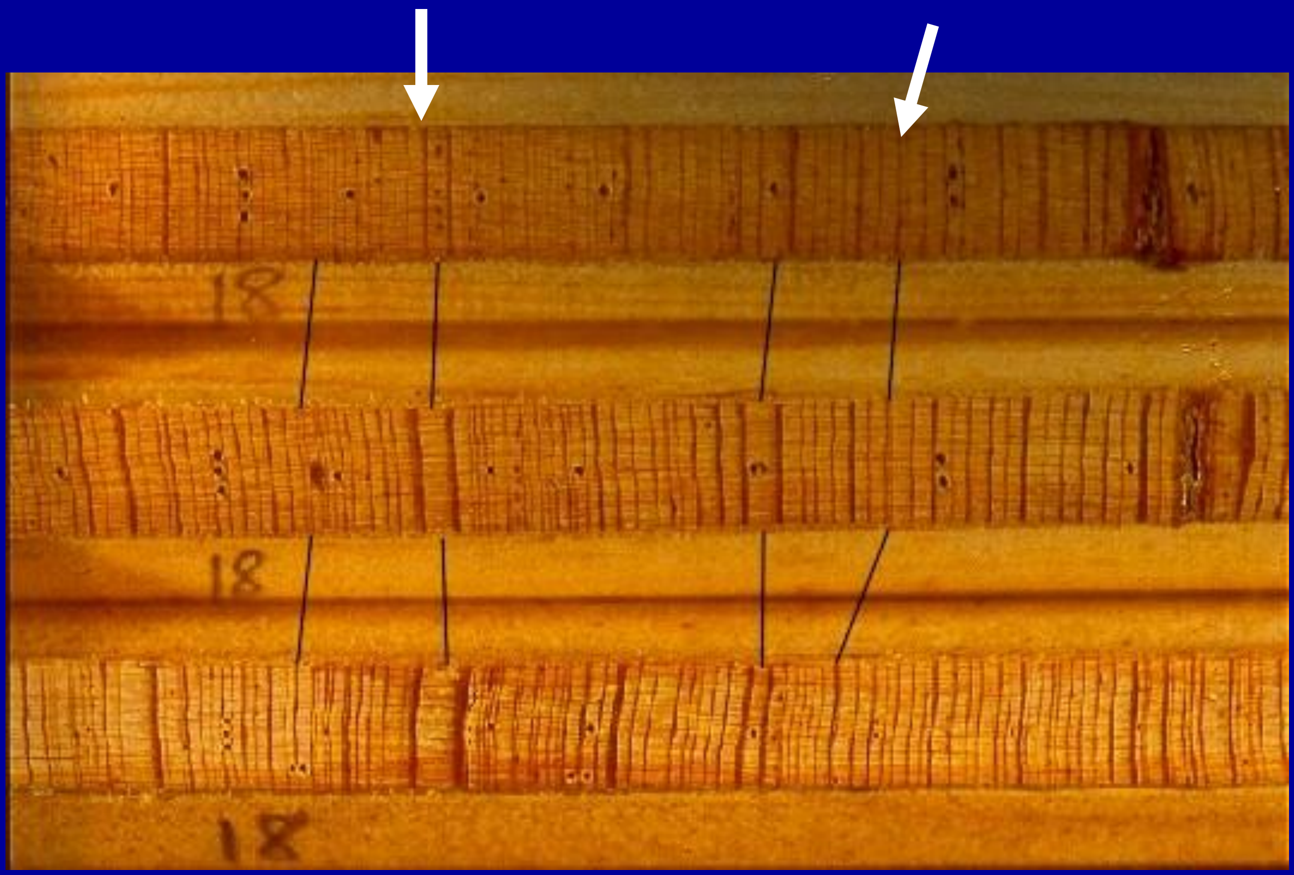


"Complacent" tree growth:

- 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 narrows rings across trees is harder when not much variation exists

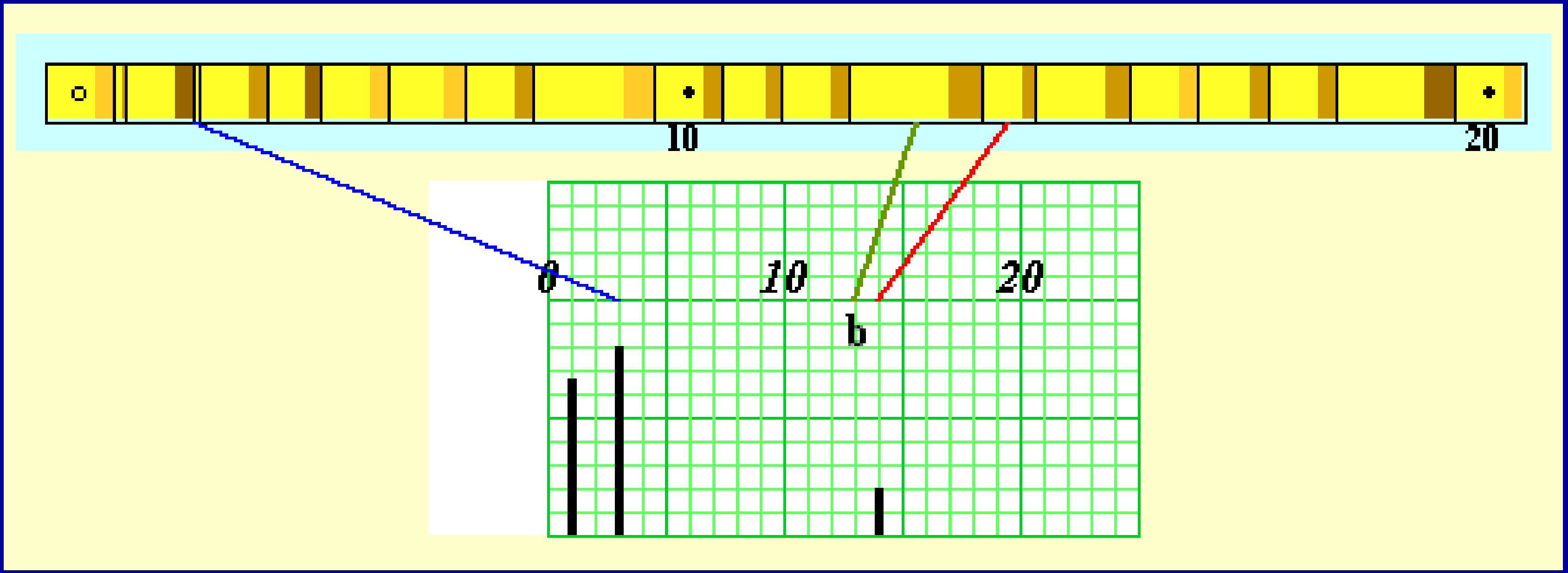
CROSSDATING –

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



Key Principles p 49

MAKING SKELETON PLOTS OF A TREE-RING CORE

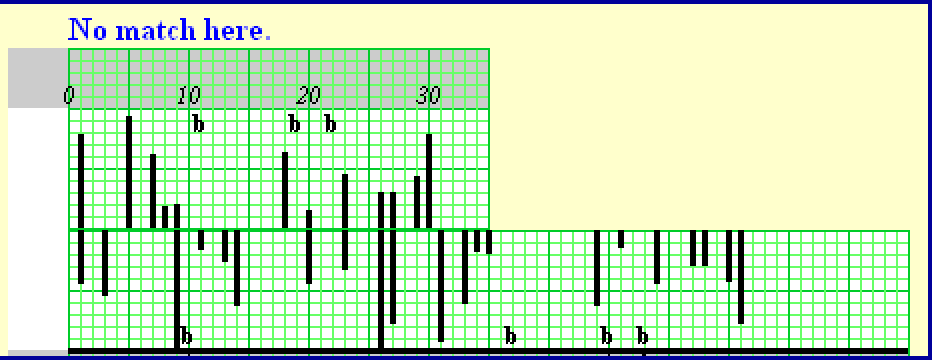


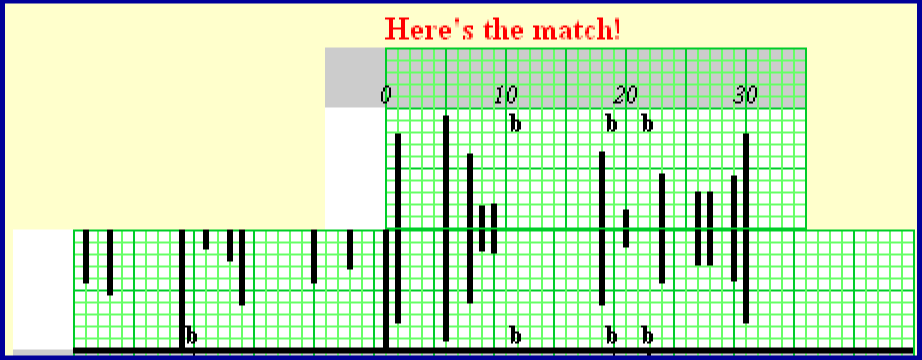
You plot a line for each NARROW ring, the narrower the ring, the longer the line!

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

PATTERN MATCHING

You match the pattern of the skeleton plot from the undated core with a "master" skeleton plot of previously dated trees at or near your site:

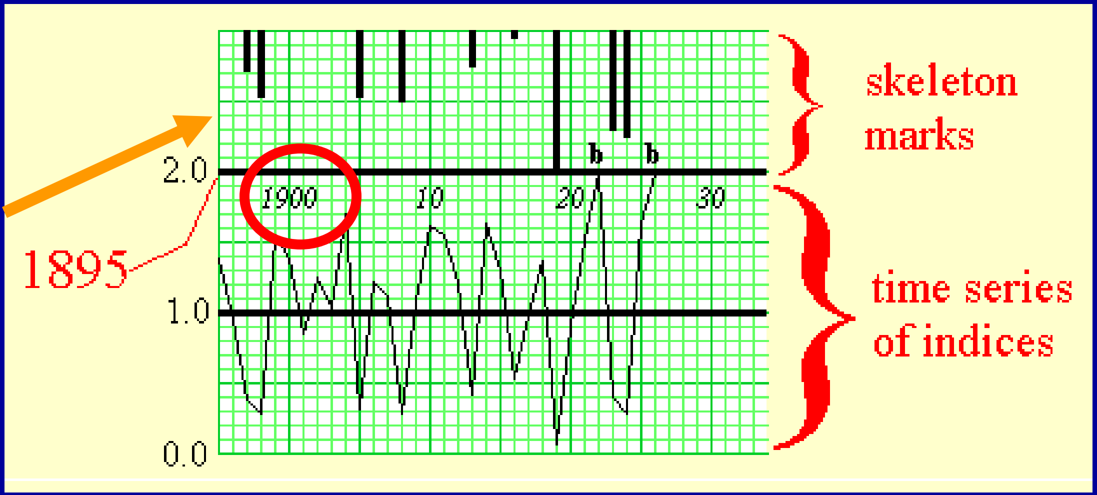




http://www.ltrr.arizona.edu/skeletonplot/patternmatching.htm

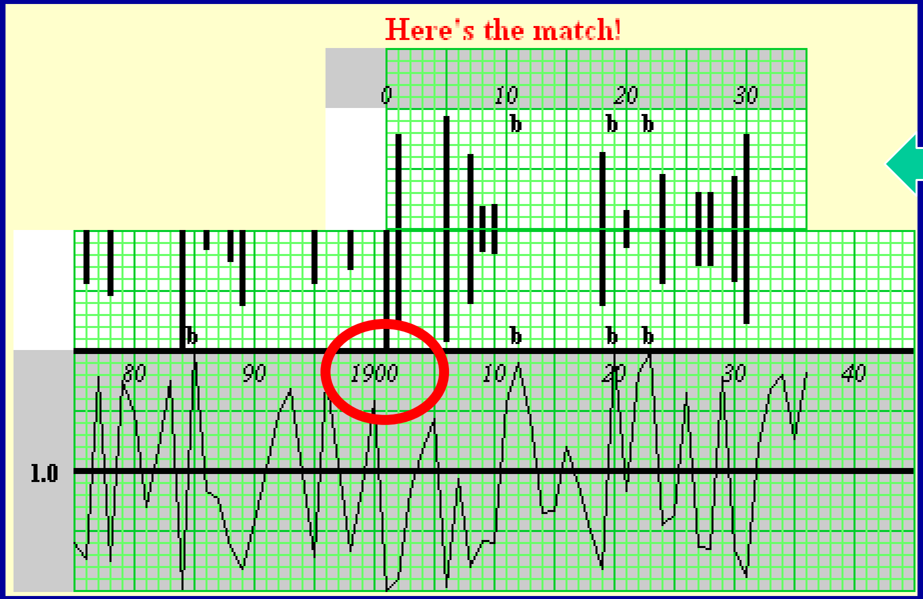
The **MASTER CHRONOLOGY** is based on previously measured and dated tree rings from the same area and includes a master skeleton plot AND tree-ring width measurements (indices)

Actual calendar dates



THEN, AFTER PATTERN MATCHING – WE CAN ASSIGN ACTUAL CALENDAR DATES!

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



Now we know the calendar dates of the core's skeleton plot

This is CROSSDATING!

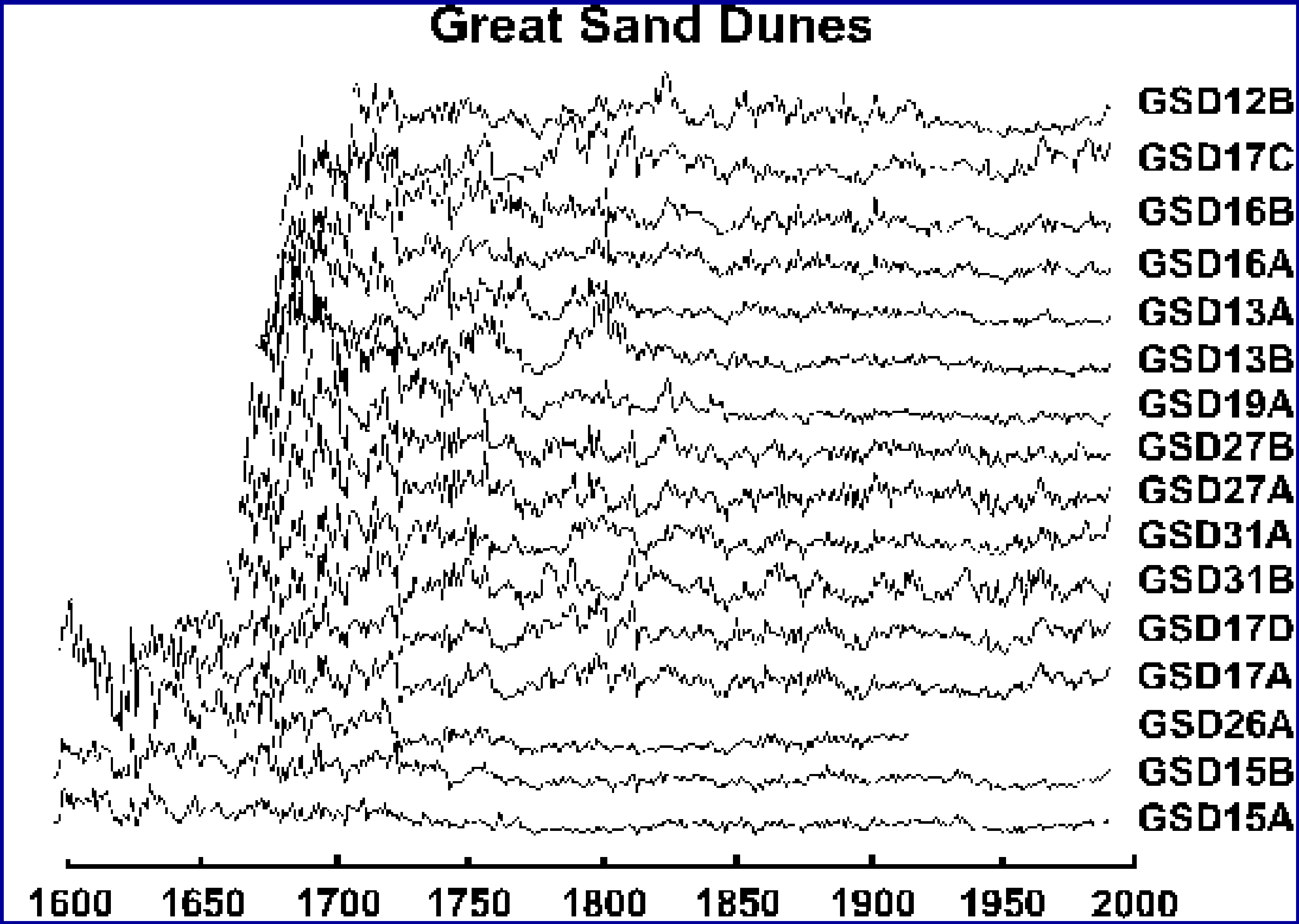
Individual Assignment I-2 will teach you how!!

Now, back to the principles:

REPLICATION –

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

Key Principles p 49


Great Sand Dunes
GSD12B
GSD17C
GSD16B
GSD16A
GSD13A
GSD13B
GSD19A
GSD27B
GSD27A
GSD31A
GSD31B
GSD17D
GSD17A
GSD26A
GSD15B
GSD15A
1600
1650
1700
1750
1800
1850
1900
1950
2000

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

Key Principles p 49

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)

Wednesday's class activity

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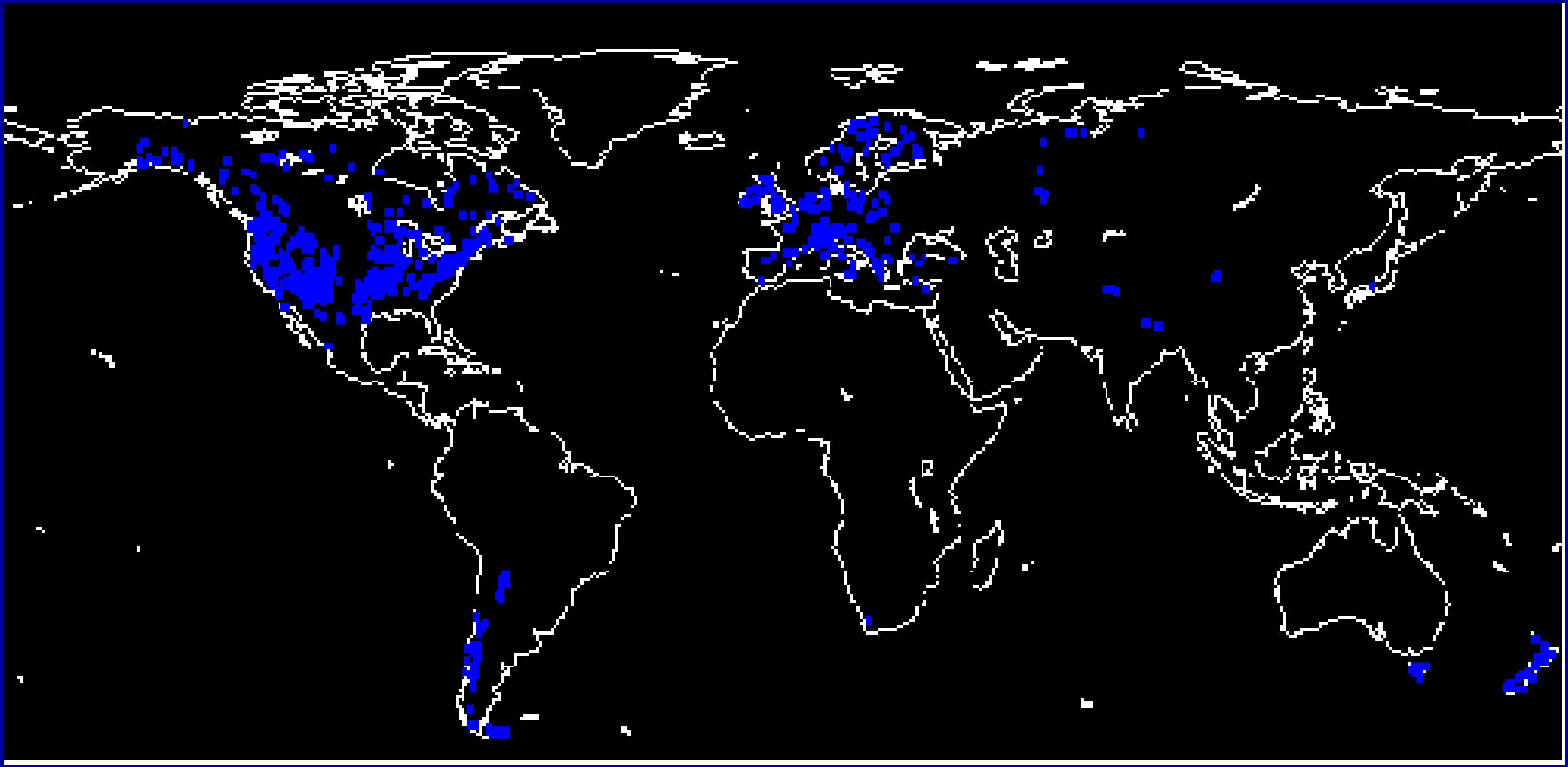
- **Geographical limitations** tropics, deserts and other treeless areas, oceans, etc.)



- **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)

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