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# LANDFORM DATING, PROCESS RECONSTRUCTIONS

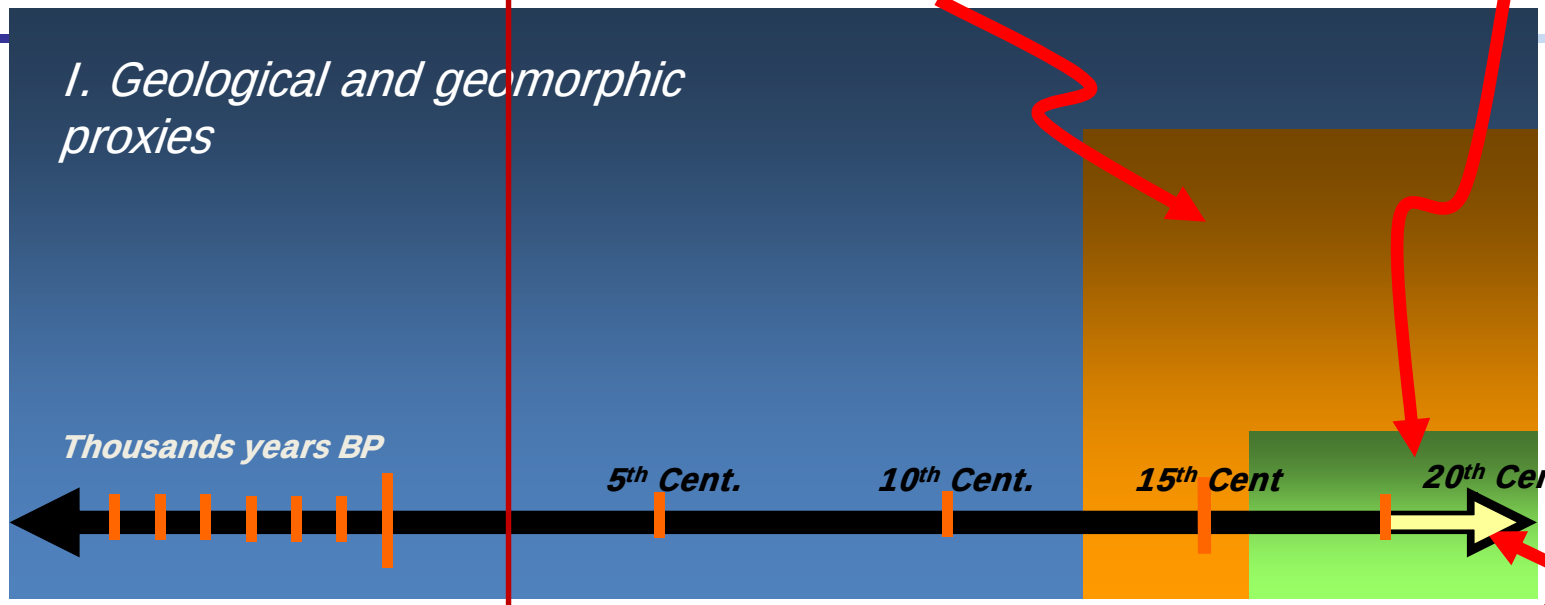
, Dr. Virginia Ruiz-Villanueva
(virginia.ruiz@dendrolab.ch)
And Prof. Markus Stoffel

IHCAP – Indian Himalayas Climate Change Adaptation Programme
Capacity building programme “Cryosphere” Level-1 (September 10, 2014)

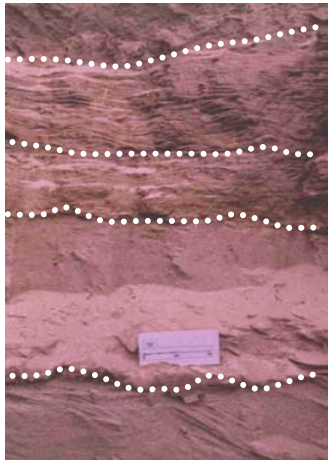
*II. Historical proxies*

*III. Biological proxies*

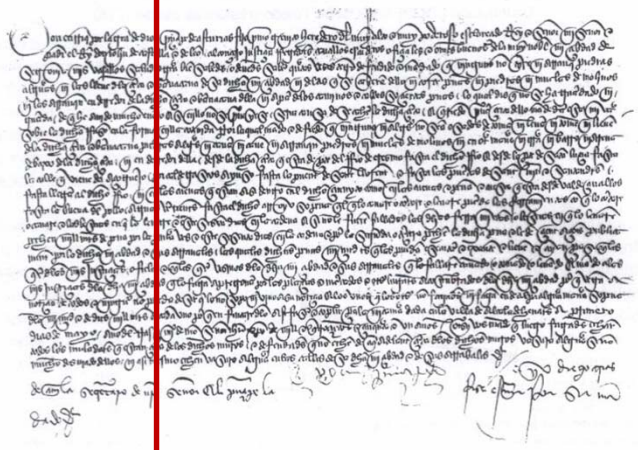
*I. Geological and geomorphic proxies*




**Instrumental data series**



Facies



Documentary sources

Tree rings and lichens

# PROCESS RECONSTRUCTIONS

Existing data on past events is not complete, and that more data is needed to understand the processes more fully:

- *the magnitude and frequency of past natural phenomena (floods, landslides…)*
- *the vulnerability of past societies to climate extremes and natural hazards.*

*Having a better knowledge of past natural disasters may allow more efficient environmental management in the future.*


Even if the past might not be 1:1 the key to the future, a good understanding of what went on in the past will be extremely helpful to fine-tune models (calibration, validation) so that one can then do scenario-based modeling

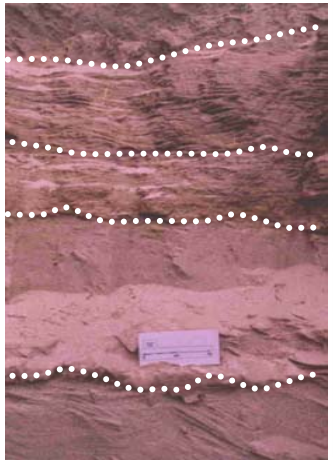
*II. Historical proxies*

*III. Biological proxies*

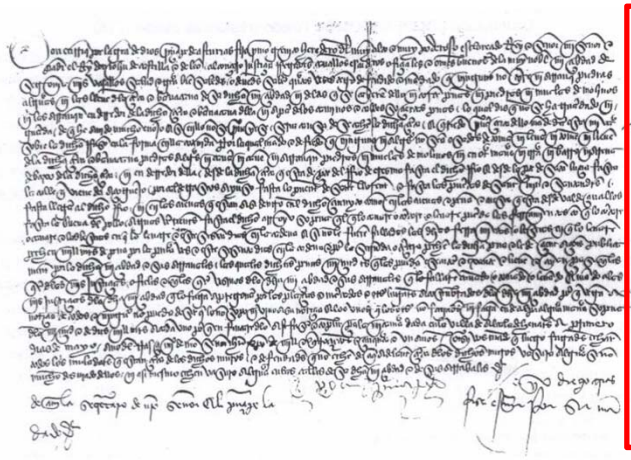
*I. Geological and geomorphic proxies*

***Thousands years BP***

***5th Cent.*** ***10th Cent.*** ***15th Cent*** ***20th Cent***



Facies



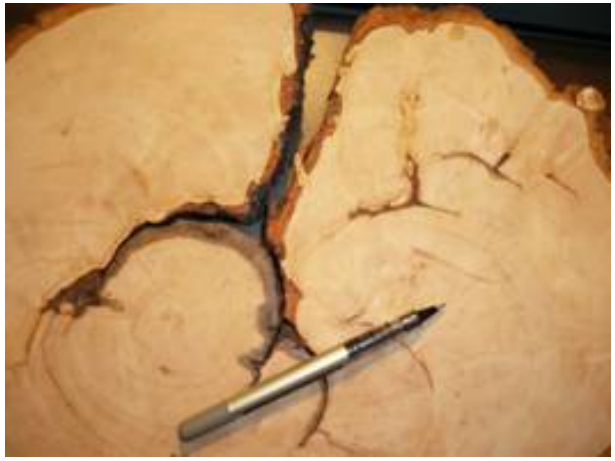
Documentary sources

Tree rings and lichens

# BOTANICAL SOURCES

## Tree rings:

1. What is dendrochronology?
2. Application fields
3. Natural processes and tree rings: Dendrogeomorphology
6. Methodologies



# What is dendrochronology?

**The aim is to develop annual tree-ring chronologies which allow to date natural events or analyze different environmental parameters**

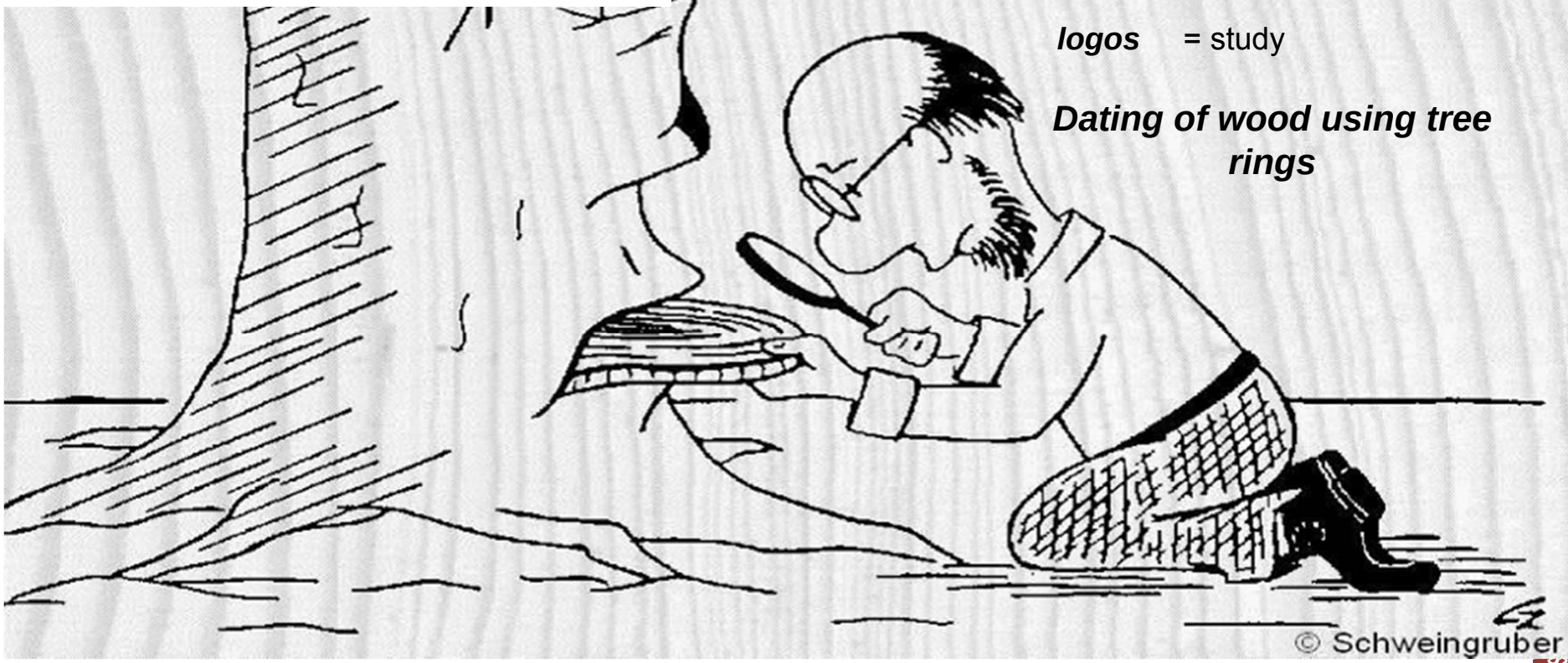
## *Dendrochronology*

***dendron*** = tree-rings

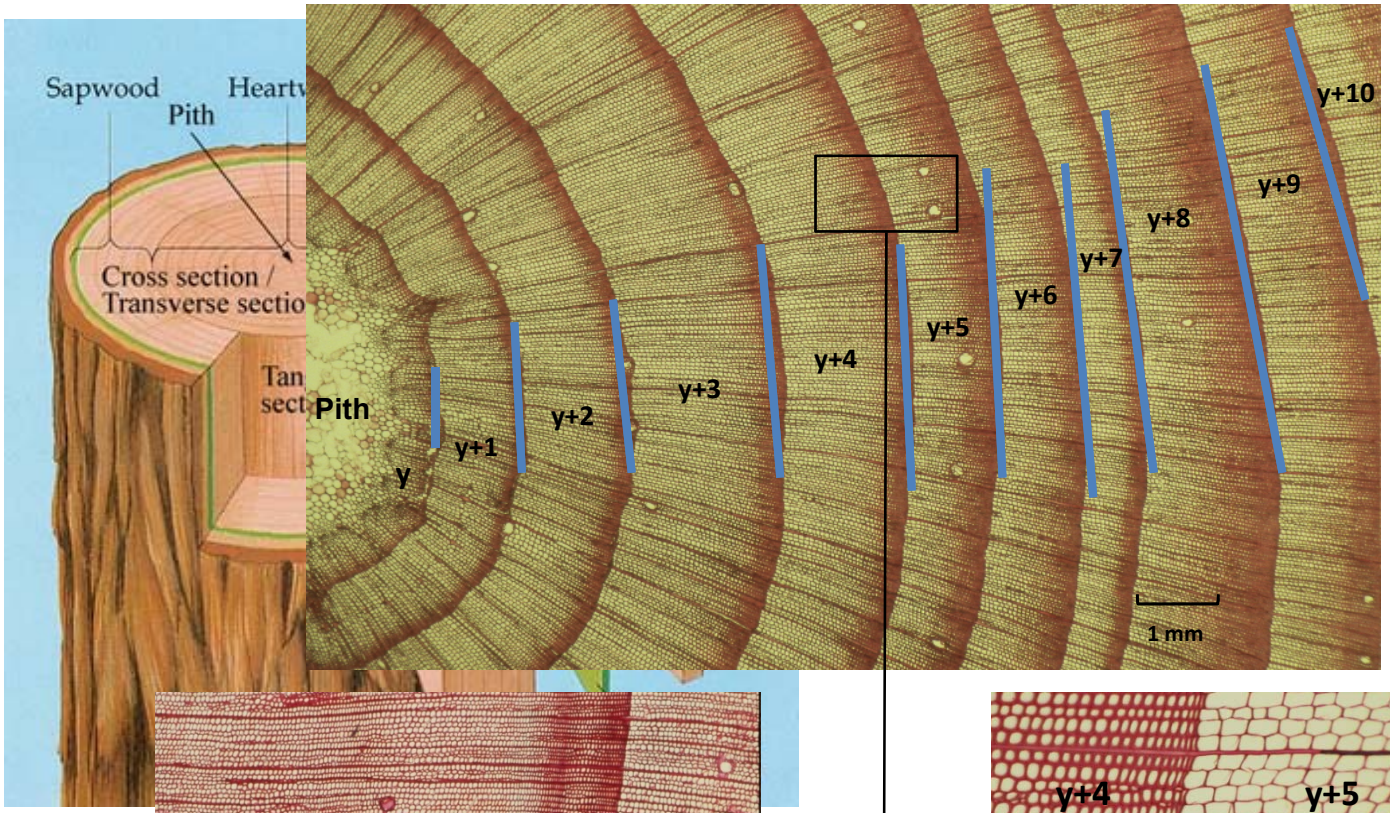
***chronos*** = time

***logos*** = study

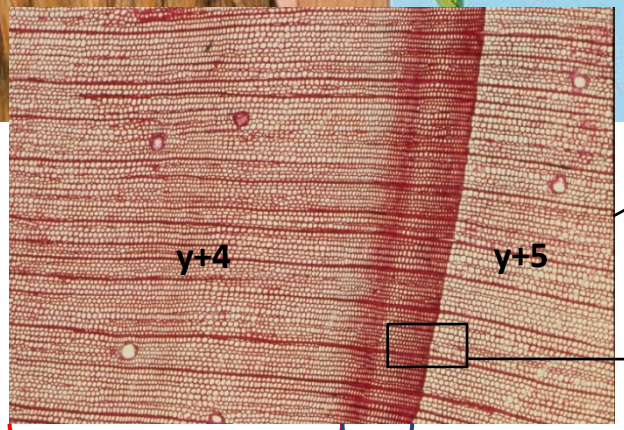
***Dating of wood using tree rings***

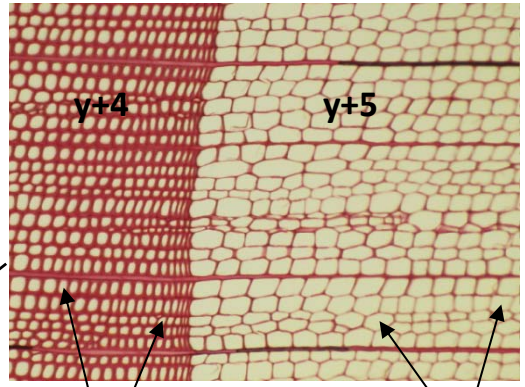


# What is dendrochronology?



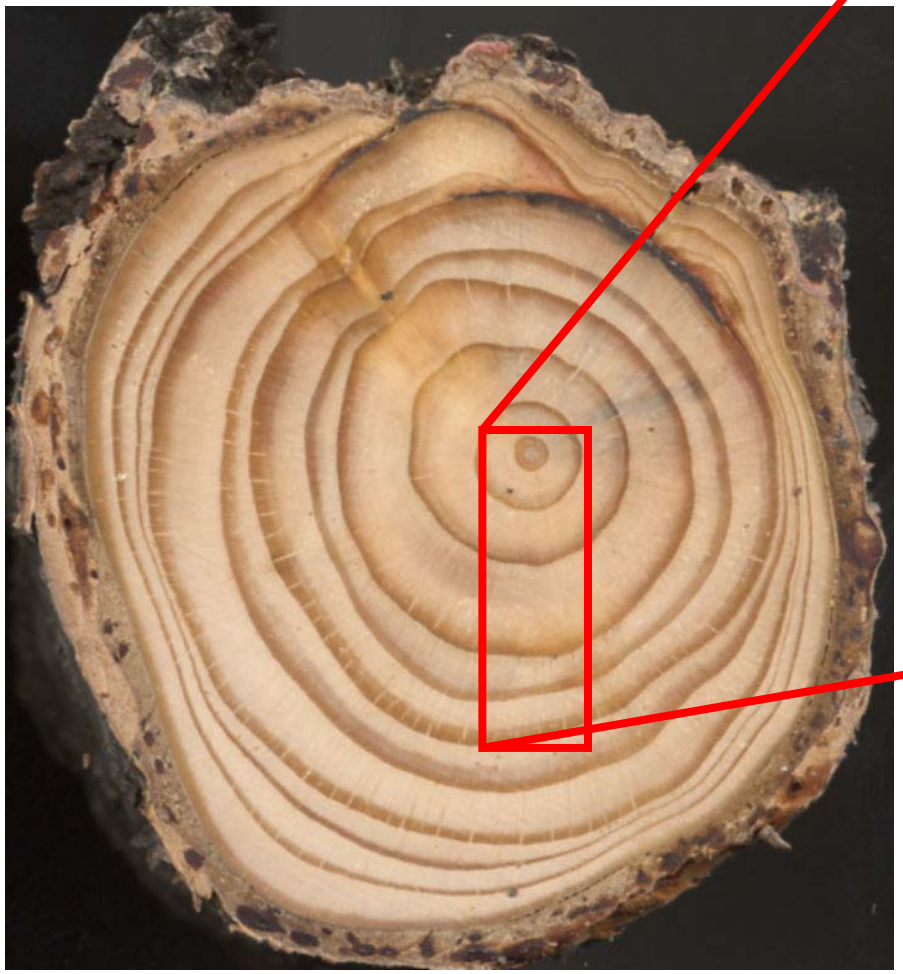

*Picea abies* (L.) Karst.

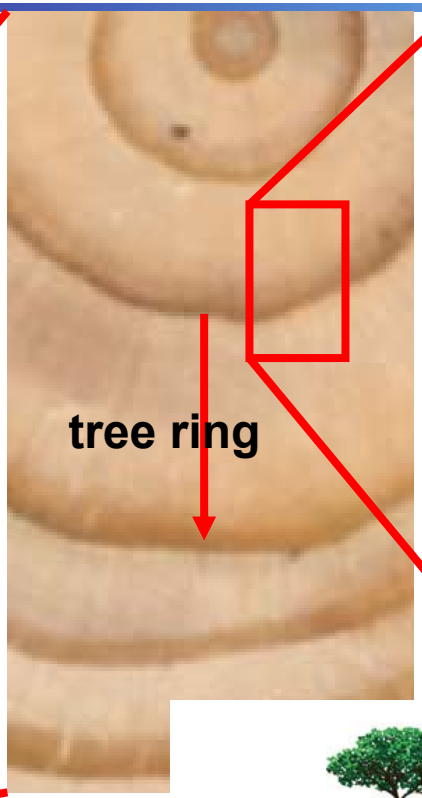


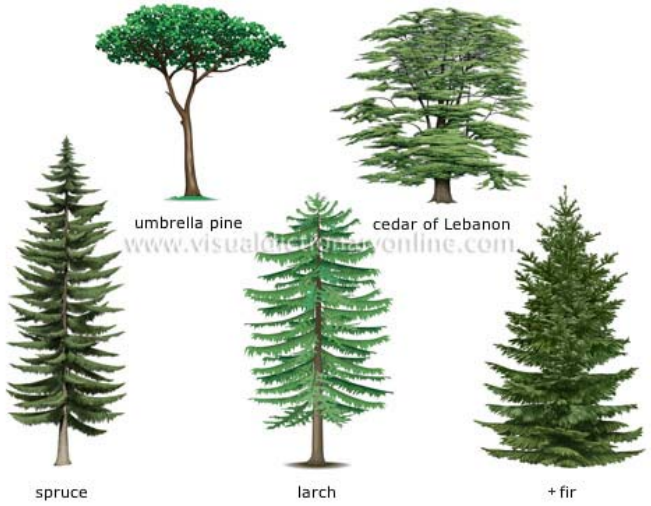



# What is dendrochronology?

## Conifers





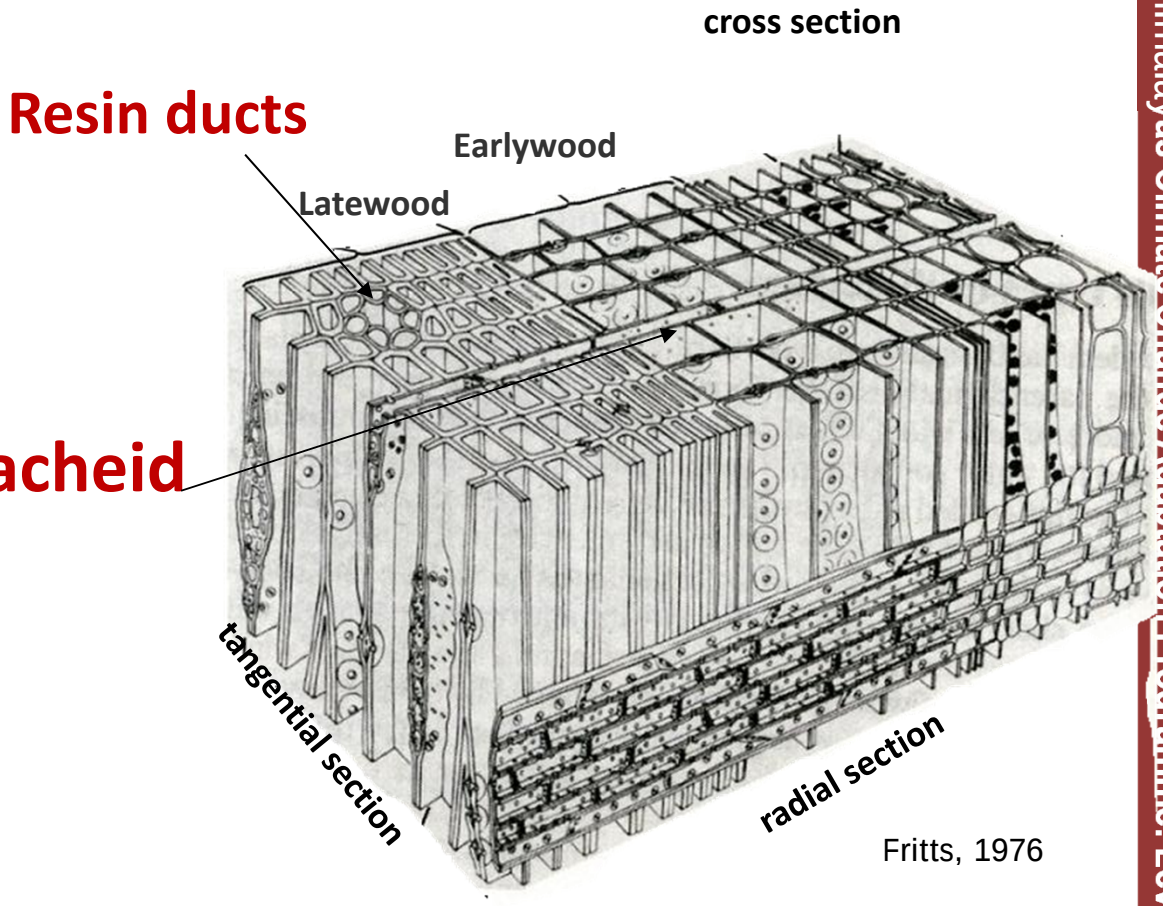



# What is dendrochronology?

## Coniferous wood

1) **Axial system:**
   - tracheids
2) **Radial system:**
   - radial cells (parenchyma)
   - Heterocellular rays (parenchyma and tracheids)

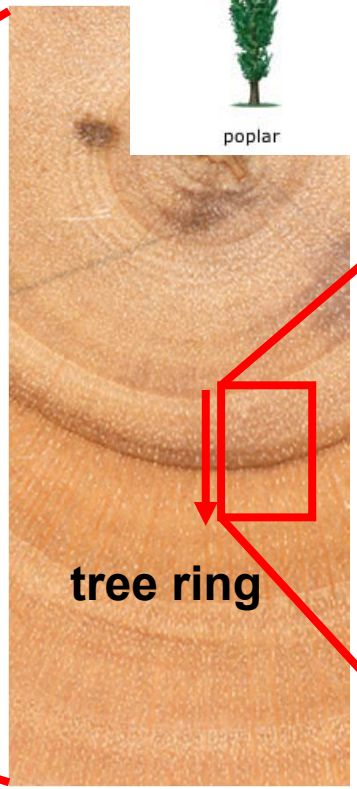
**Others interesting feature: resin ducts**

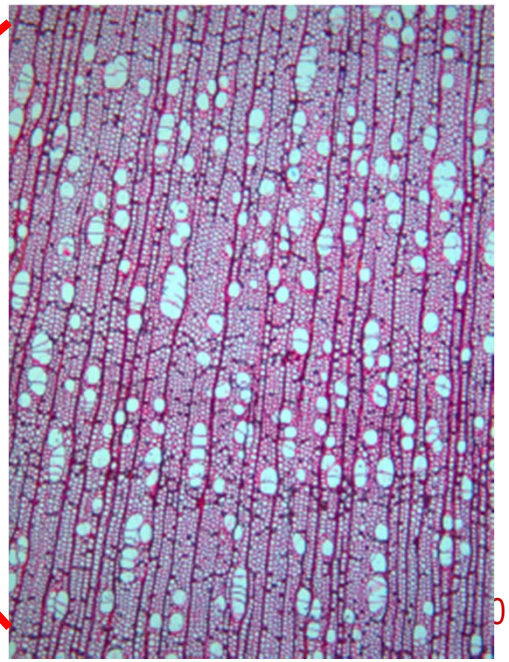



Fritts, 1976

# What is dendrochronology?

## Broadleaved trees

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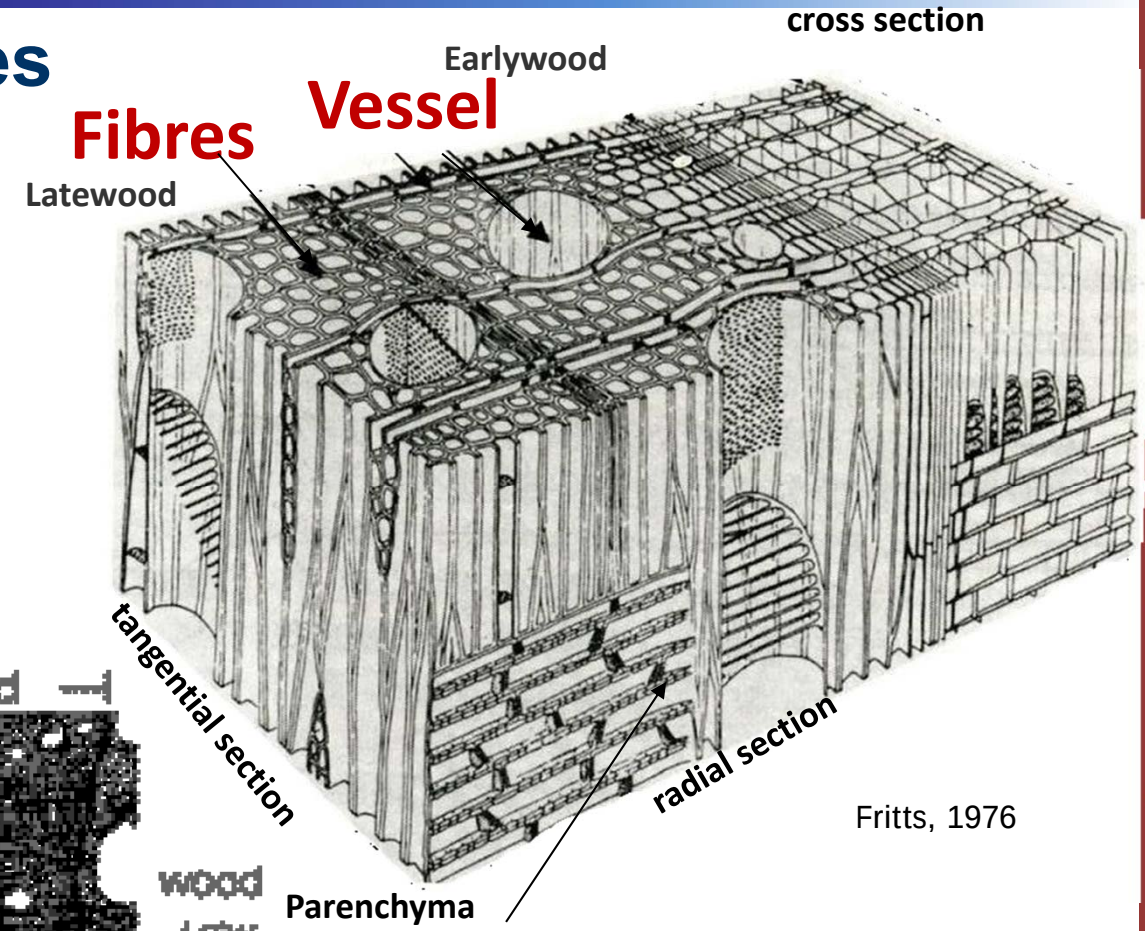
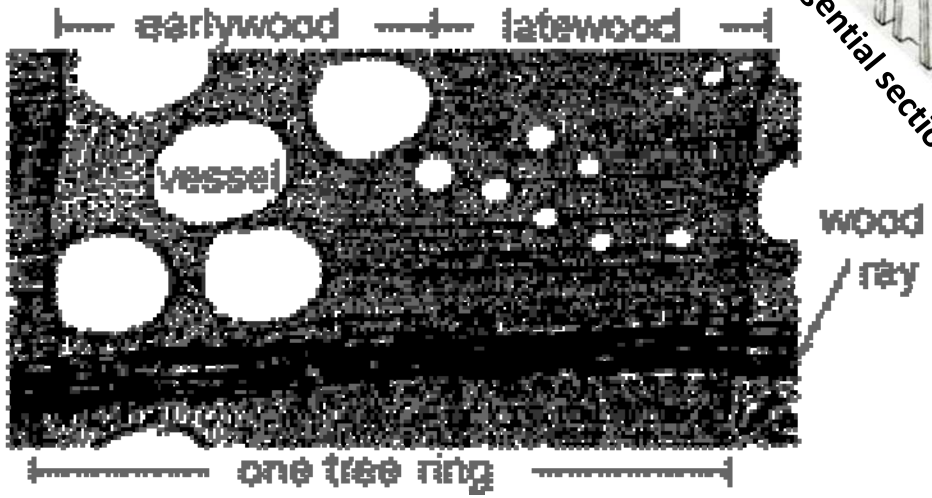
## Broadleaved trees




Fritts, 1976



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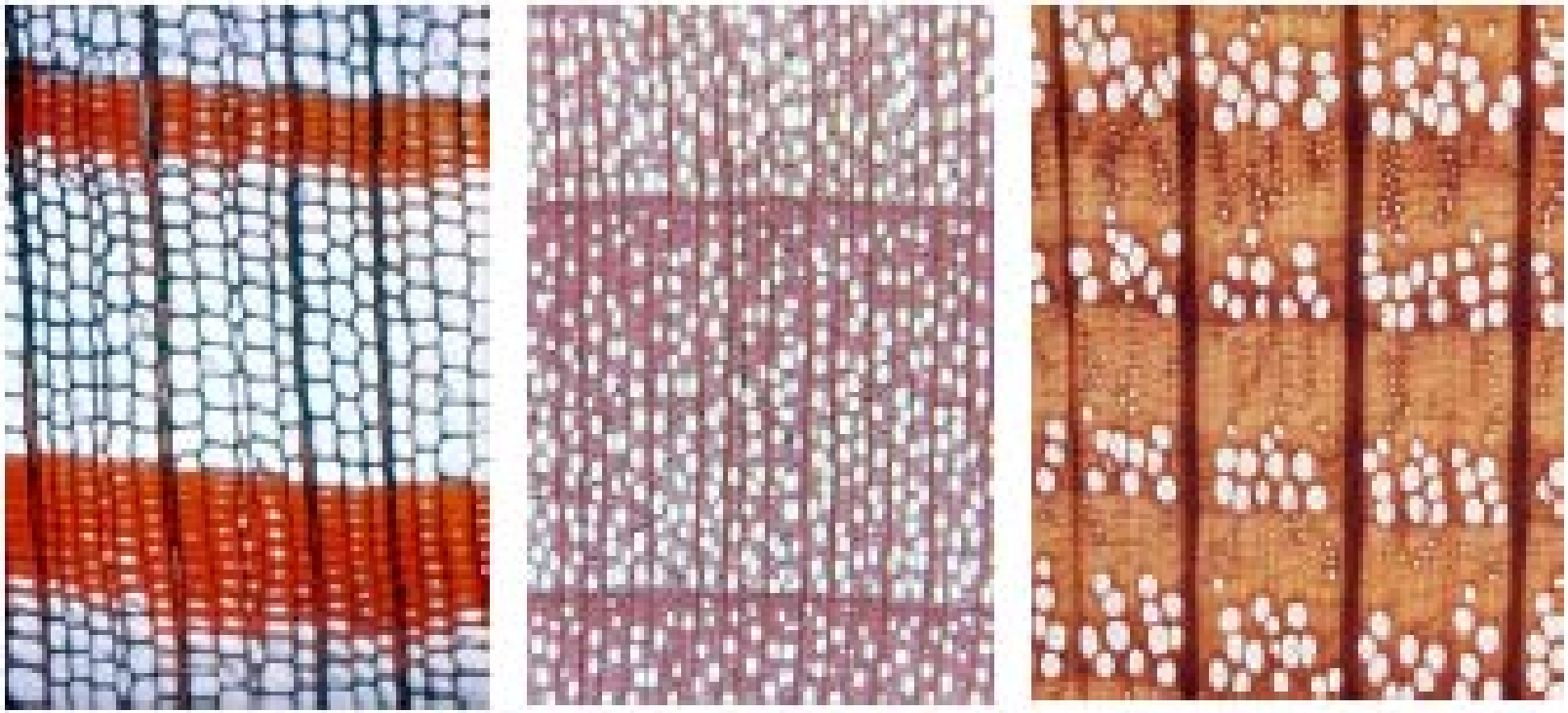
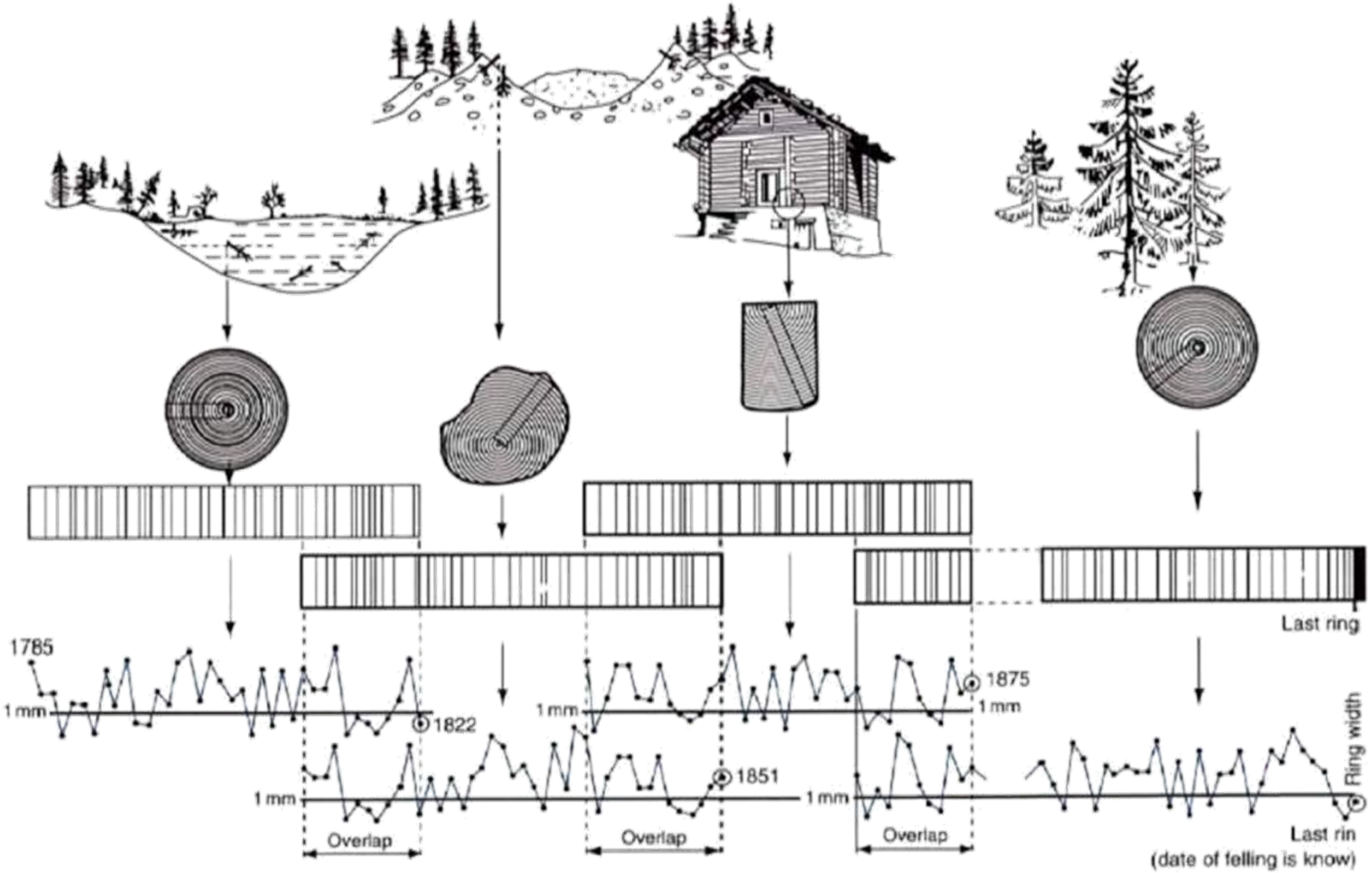


# What is dendrochronology?

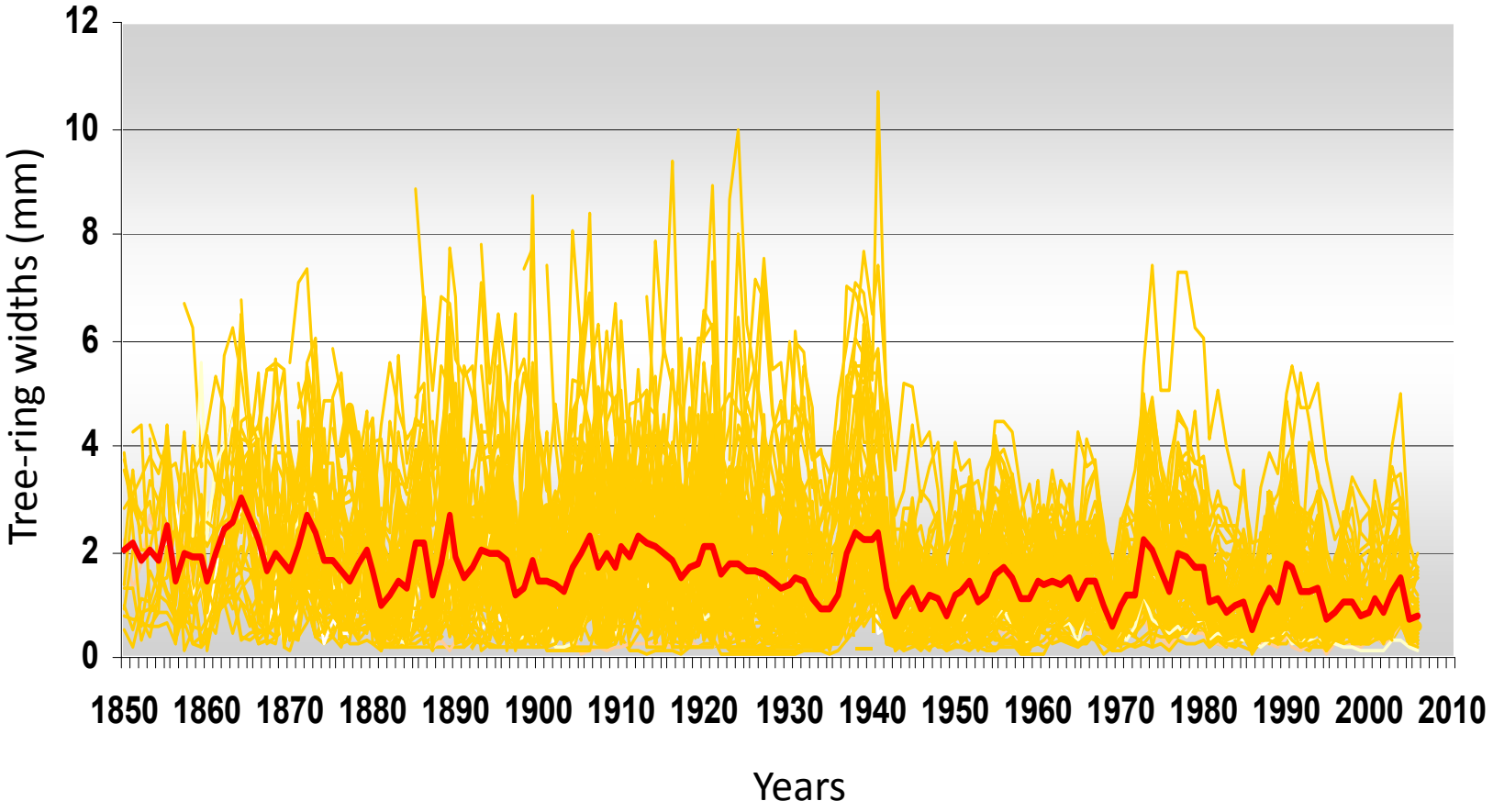
From where do we get tree-ring information?

**The aim is to develop annual tree-ring chronologies**



# What is dendrochronology?

***Crossdating Principle.*** Different human and environmental factors are likely to influence tree growth in uniform physiographic area in a similar way and through a comparable variability in tree-ring width. The characterization of these patterns allows to date and synchronize tree-ring series and to position them correctly in time by using various statistical techniques.



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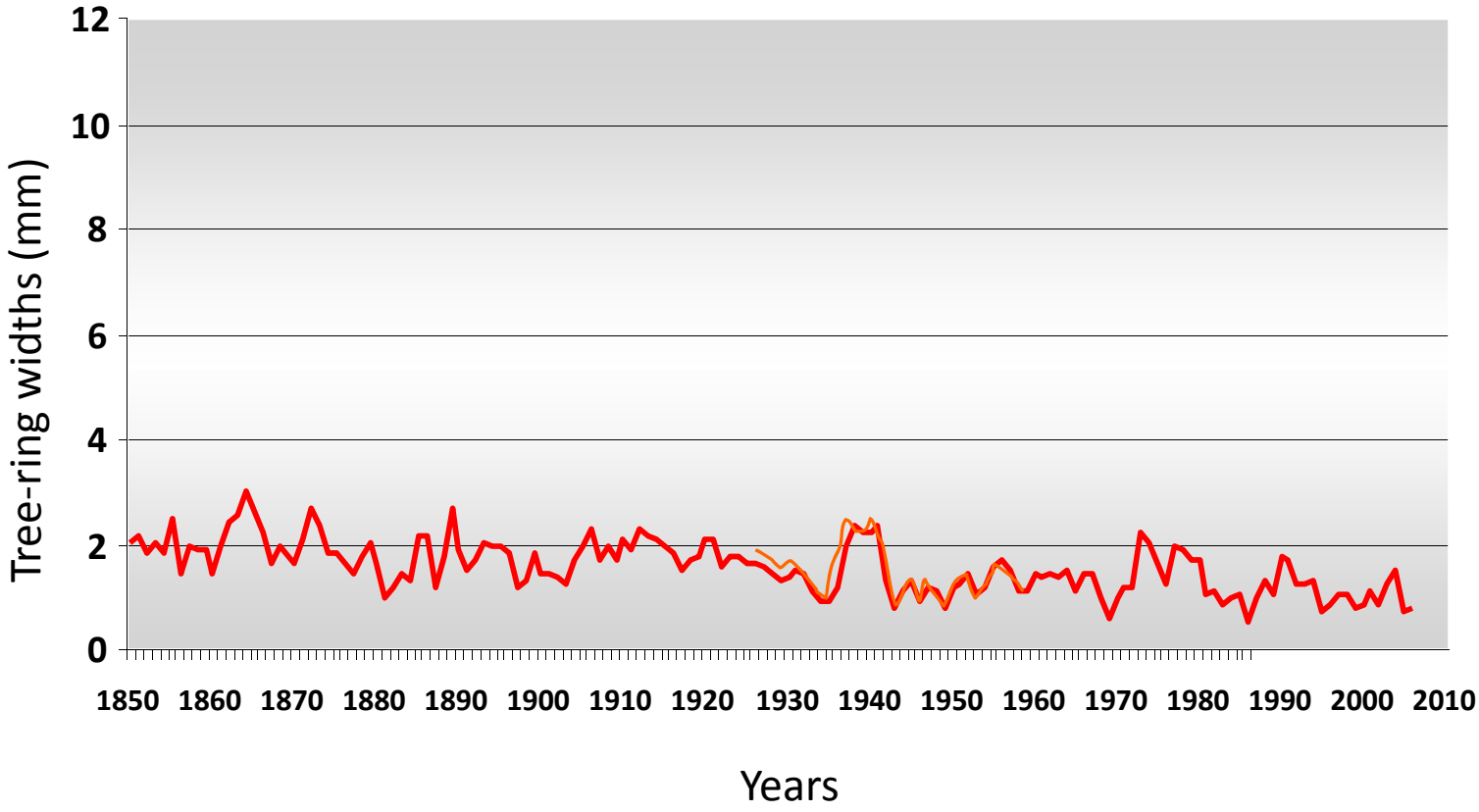

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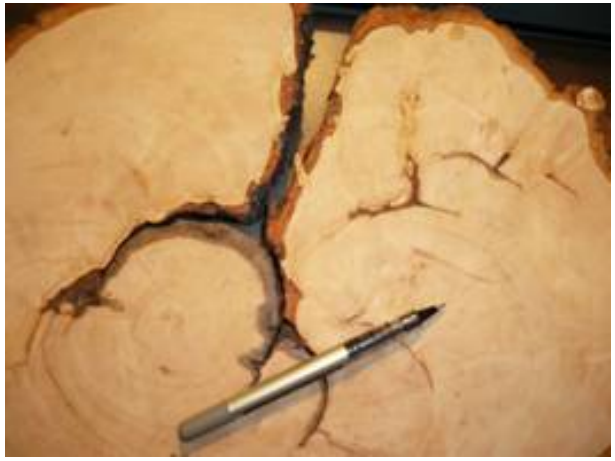
6. Methodologies



# Application fields

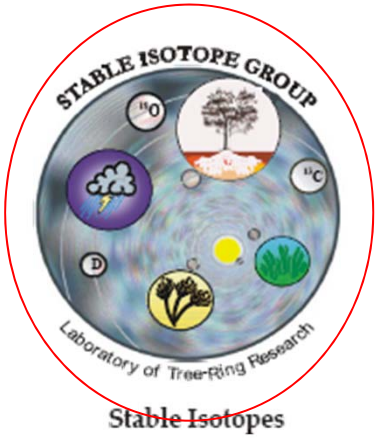
## Application fields


Climatology

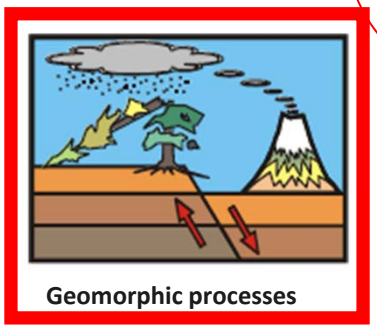

Fire History

Ecology

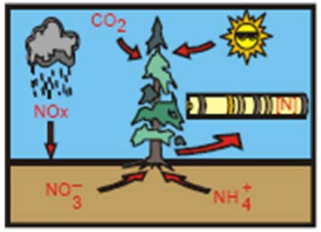
Archaeology



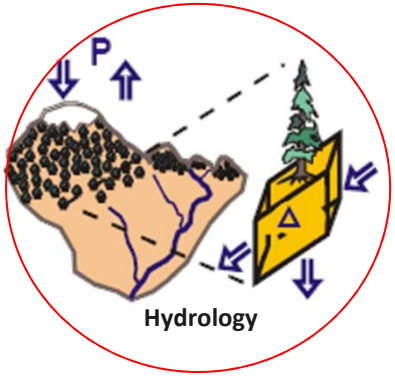

Stable Isotopes



Geomorphic processes




Biogeochemistry




Hydrology

# Application fields: «Tree as a weather station»

- Dendroclimatology

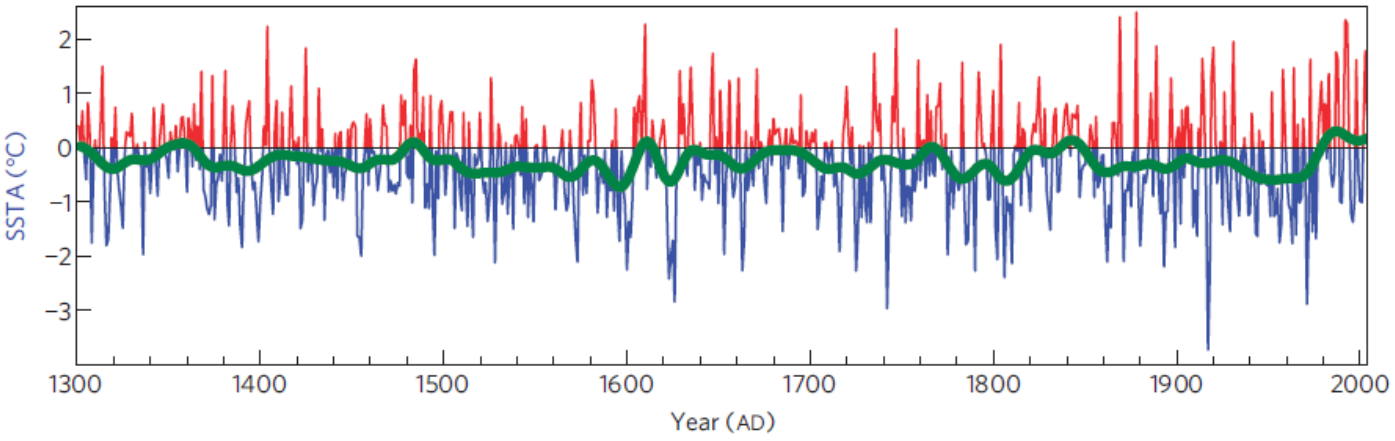
Aims :

✓ Investigating the trees' response to climate

✓ Reconstructing past climate

Several climatic parameters can be reconstructed using tree rings:

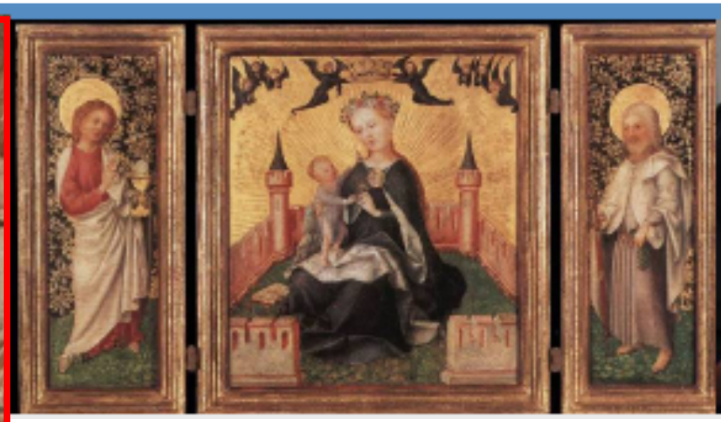
✓ Temperature
✓ Precipitation
✓ Drought
✓ Streamflow
✓ Snowpack
✓ NOA index
✓ ENSO Index

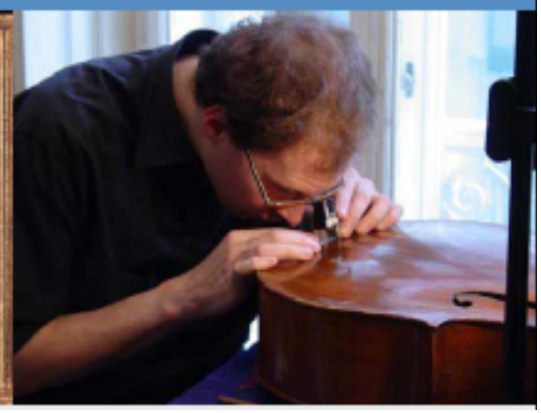



ENSO reconstruction, Yang et al., 2013, *Nature Climate Change*

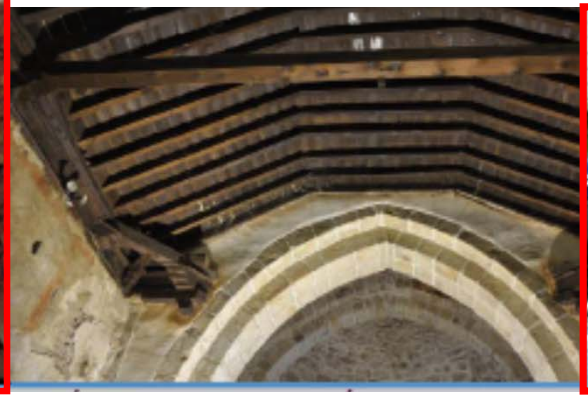
# Application fields: archaeology

- Dendroarchaeology

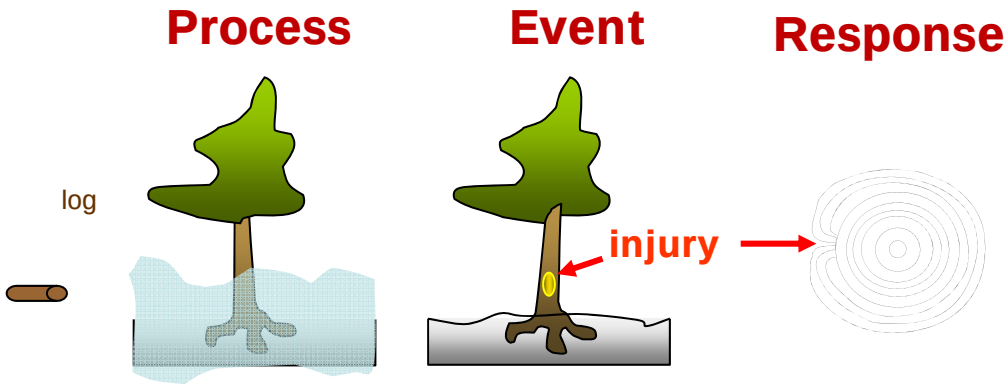




**Building structures or human settlements, furniture, musical instruments, old boats, or sub-fossil material**



# Application fields: dendrogeomorphology



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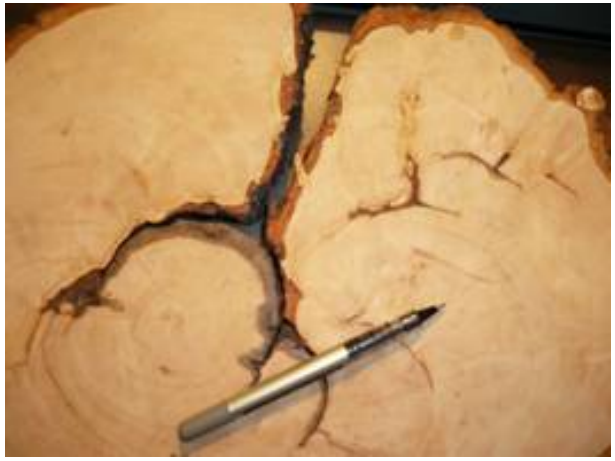


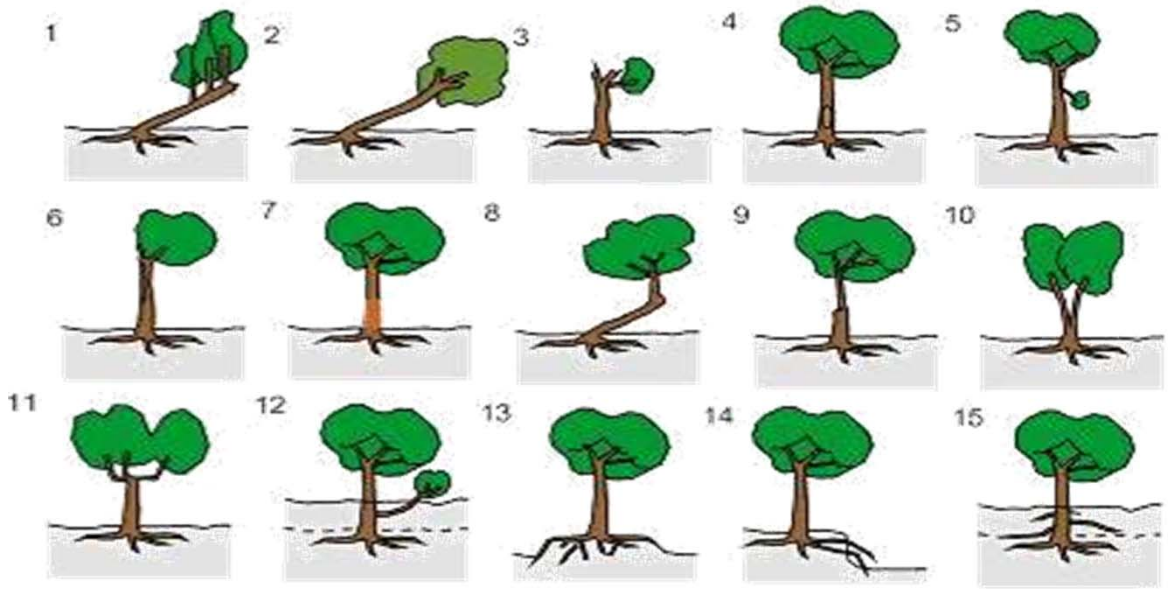
# Dendrogeomorphology

**What geomorphic processes can influence tree growth?**

- Debris flow
- Rockfall
- Avalanches
- Land slides
- Erosion processes
- Floods / inundations
- Volcanoes (lahars)
- Glacier lake outburst flood
- …

# Dendrogeomorphology

## DENDROGEOMORPHOLOGICAL EVIDENCE




*1 - tree chandelier, 2 - foot inclined, 3 - beheaded; 4 - scars, 5 - boot branches 6 - friction from falling neighbor trees; 7 - erosion, 8 - elbows and angles, 9 - sudden narrowing of the shaft , 10 - forks, 11 - elbows and angles in branches 12 - shoots from buried logs, 13 - exposed roots; 14 - floating roots, 15 - new roots from buried logs.*

| SPACIAL SCALE | | STUDIED ELEMENT | | | TYPE OF DENDROGEOMORPHOLOGICAL INDICES | | No. |
|---|---|---|---|---|---|---|---|
| km<br>hm | Macroscopic | Bottomland vegetation patterns | | | Species distribution pattern<br>Coverage distribution pattern<br>Ages distribution pattern | | ID 1<br>ID 2<br>ID 3 |
| | | Individual (tree or bush) | Complete tree or bush | | Candelabra growth<br>Tilted and overturned trees<br>Decapitated trees (tops missing) | | ID 4<br>ID 5<br>ID 6 |
| dm | | | Part of tree or bush | Trunk | Stripped bark with callus marks | Sediment load impact | ID 7 |
| | | | | | | Branches torn off | ID 8 |
| | | | | | | Scraping from other falling trees | ID 9 |
| | | | | | Erosion | | ID10 |
| m | | | | | Sudden narrowings in trunk | | ID 11 |
| | | | | | Elbows and angles | | ID 12 |
| | | | | | Bifurcations | | ID 13 |
| | | | | | Sprouts from buried trunks | | ID 14 |
| dm | | | | Branches | Sprouts from buried trunks | | ID 15 |
| | | | | | Elbows and angles | | ID 16 |
| cm | | | | Roots | Exposed roots | Stripped bark and erosion | ID 17 |
| | | | | | | Float roots without substrate contact | ID 18 |
| | | | | | New roots from buried trunks | | ID 19 |
| mm | Mesoscopic | Tissues, wedges and slices | | Rings | Eccentric growths (reaction wood) | | ID 20 |
| | | | | | False tree rings | | ID 21 |
| | | | | | Discontinuities, erosion, and internal scars | | ID 22 |
| | | | | Tissues | Changes in parameters (width, % early wood, late wood, etc) | | ID 23 |
| | Microscopic | Thin slice | | | Ratio parenchyma-lignification tissue | | ID 24 |
| | | | | | Size and density of vessels | | ID 25 |
| µm | | | | Cells | Changes in cell parameters | Size and morphometry of lumen cells | ID 26 |
| | | | | | | Cell wall thickness | ID 27 |
| | | | | | Appearance and/or abundance of special types of cells | Traumatic resin ducts (TRDs) | ID 28 |
| | | | | | | Fiber-tracheid | ID 29 |
| | | | | | | Traumatic structures in cell wall | ID 30 |
| Å | Atomic | Cell wall | | Cellulose | Isotopic fractionation | $^{18}O/^{16}O$ ratio | ID 31 |

# Dendrogeomorphology

## *At large spatial scales: Species distribution*

| SPACIAL SCALE | STUDIED ELEMENT | TYPE OF DENDROGEOMORPHOLOGICAL INDICES | No. |
|---|---|---|---|
| km<br>hm | Bottomland vegetation patterns | Species distribution pattern<br>Coverage distribution pattern<br>Ages distribution pattern | ID 1<br>ID 2<br>ID 3 |

***Hippophae rhamnoides***

The presence of particular plant species reflects torrential conditions and allows a first qualitative estimation of flood frequency in one place. This applies to the presence of the shrub ***Hippophae rhamnoides*** alluvial fan in the Canyon Arás Biescas (Huesca, Spain).

# Dendrogeomorphology

## *At large spatial scales: Age distribution*

| SPACIAL SCALE | | STUDIED ELEMENT | TYPE OF DENDROGEOMORPHOLOGICAL INDICES | No. |
|---|---|---|---|---|
| km<br>hm | | Bottomland vegetation patterns | Species distribution pattern<br>Coverage distribution pattern<br>Ages distribution pattern | ID 1<br>ID 2<br>ID 3 |



***(Gottesfeld & Gottesfeld, 1989)***

Old vegetation on a deposit = minimum age of the process (+ stabilization period)

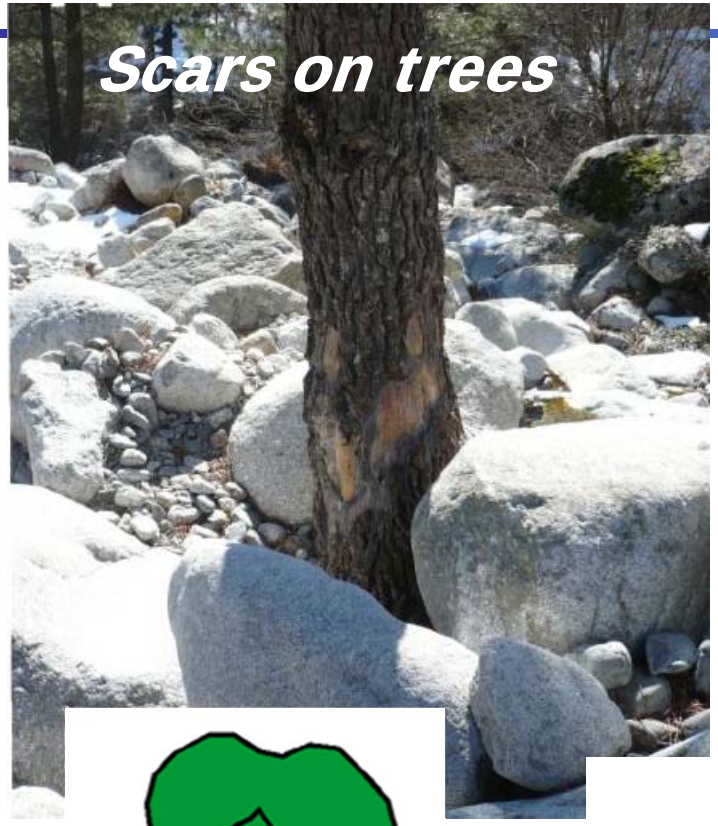
# Dendrogeomorphology

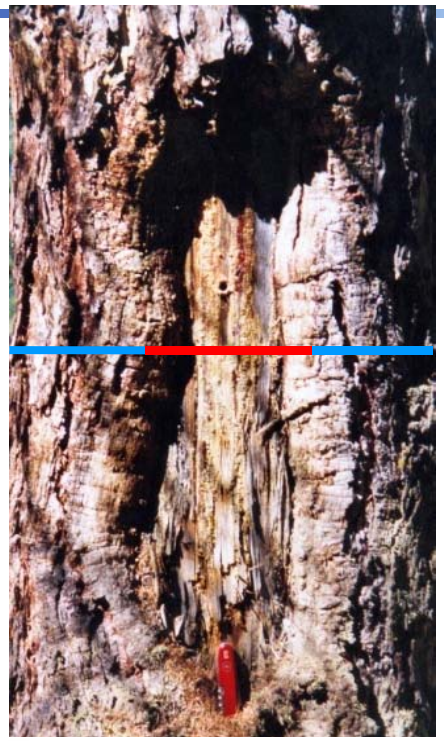
## *At local spatial scales*

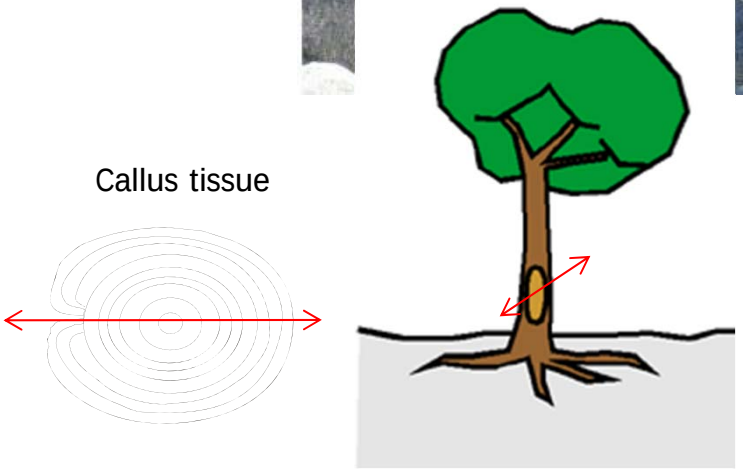
- **DENDROGEOMORPHIC EVIDENCE**

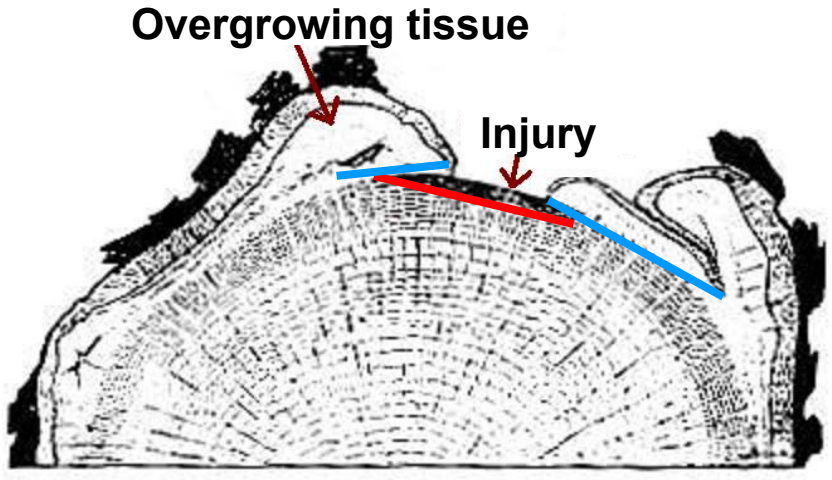
| SPACIAL SCALE | | STUDIED ELEMENT | | | TYPE OF DENDROGEOMORPHOLOGICAL INDICES | | No. |
|---|---|---|---|---|---|---|---|
| km<br>hm | Macroscopic | Bottomland vegetation patterns | | | Species distribution pattern<br>Coverage distribution pattern<br>Ages distribution pattern | | ID 1<br>ID 2<br>ID 3 |
| dm<br>m<br>dm<br>cm | | Individual (tree or bush) | Complete tree or bush | | Candelabra growth<br>Tilted and overturned trees<br>Decapitated trees (tops missing) | | ID 4<br>ID 5<br>ID 6 |
| | | | Part of tree or bush | Trunk | Stripped bark with callus marks | Sediment load impact | ID 7 |
| | | | | | | Branches torn off | ID 8 |
| | | | | | | Scraping from other falling trees | ID 9 |
| | | | | | Erosion | | ID10 |
| | | | | | Sudden narrowings in trunk | | ID 11 |
| | | | | | Elbows and angles | | ID 12 |
| | | | | | Bifurcations | | ID 13 |
| | | | | | Sprouts from buried trunks | | ID 14 |
| | | | | Branches | Sprouts from buried trunks | | ID 15 |
| | | | | | Elbows and angles | | ID 16 |
| | | | | Roots | Exposed roots | Stripped bark and erosion | ID 17 |
| | | | | | | Float roots without substrate contact | ID 18 |
| | | | | | New roots from buried trunks | | ID 19 |
| | | | | | Eccentric growths (reaction wood) | | ID 20 |

# Dendrogeomorphology

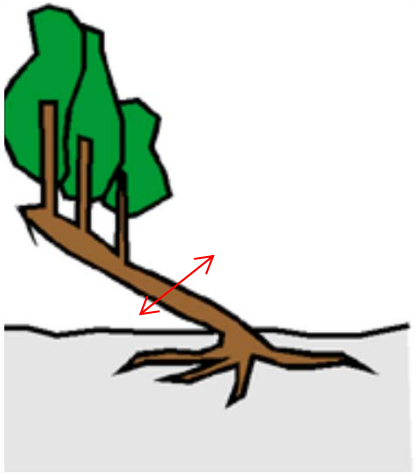


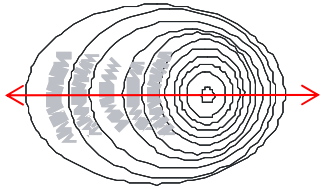


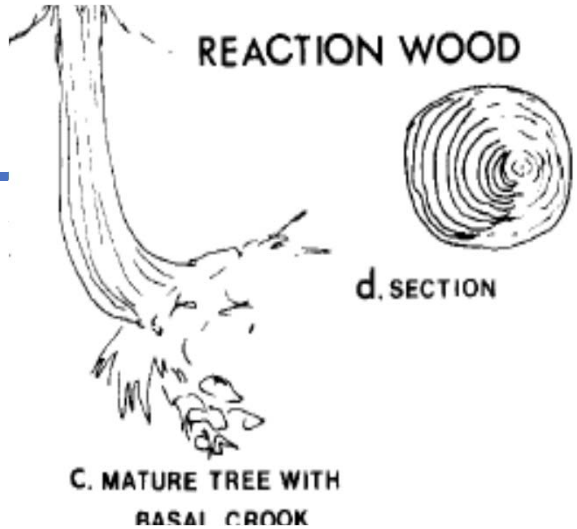



# Dendrogeomorphology

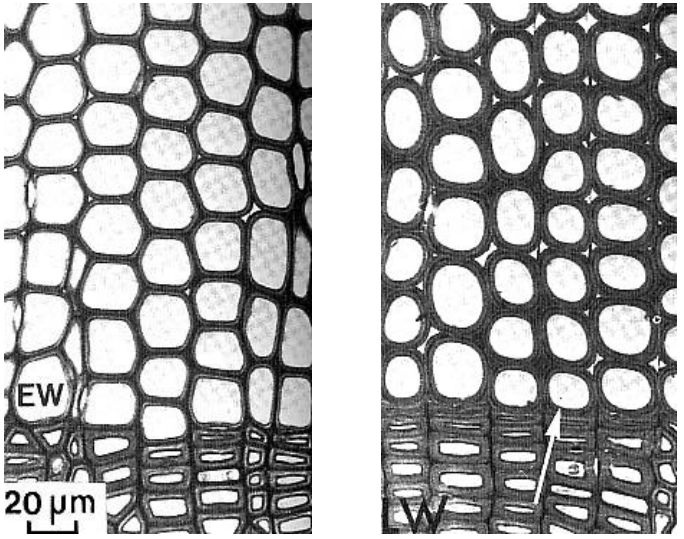



Reaction wood





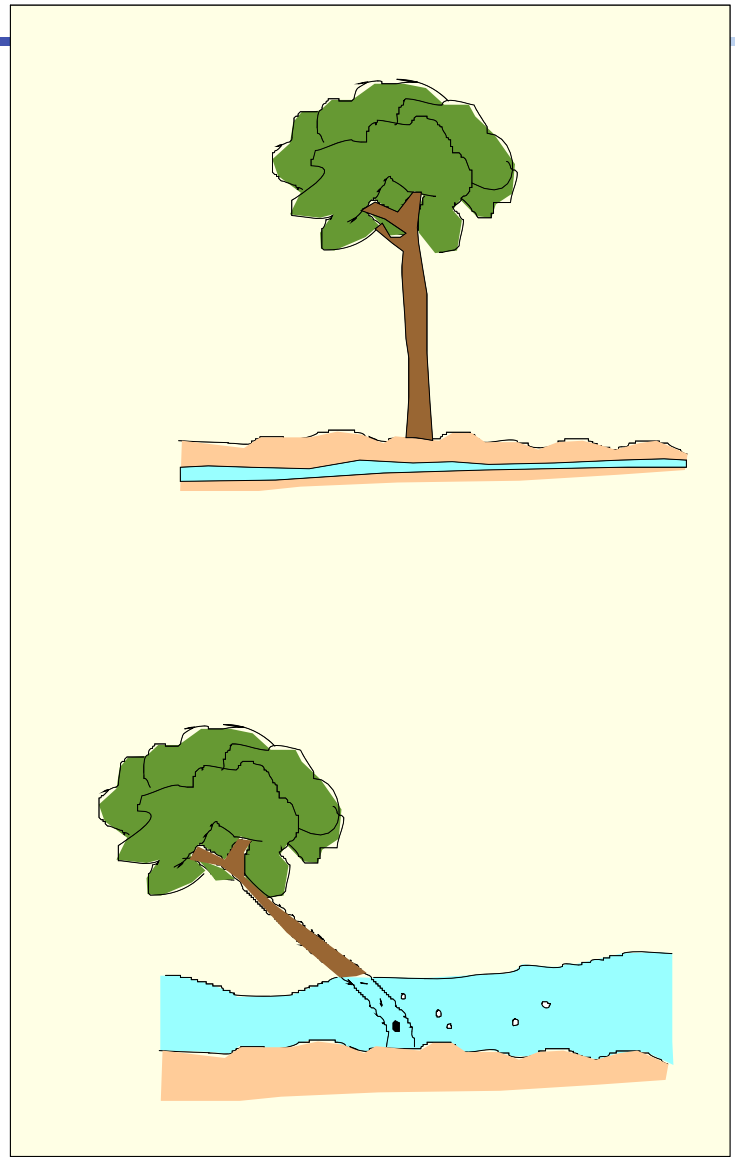

*(Gottesfeld & Gottesfeld, 1989)*



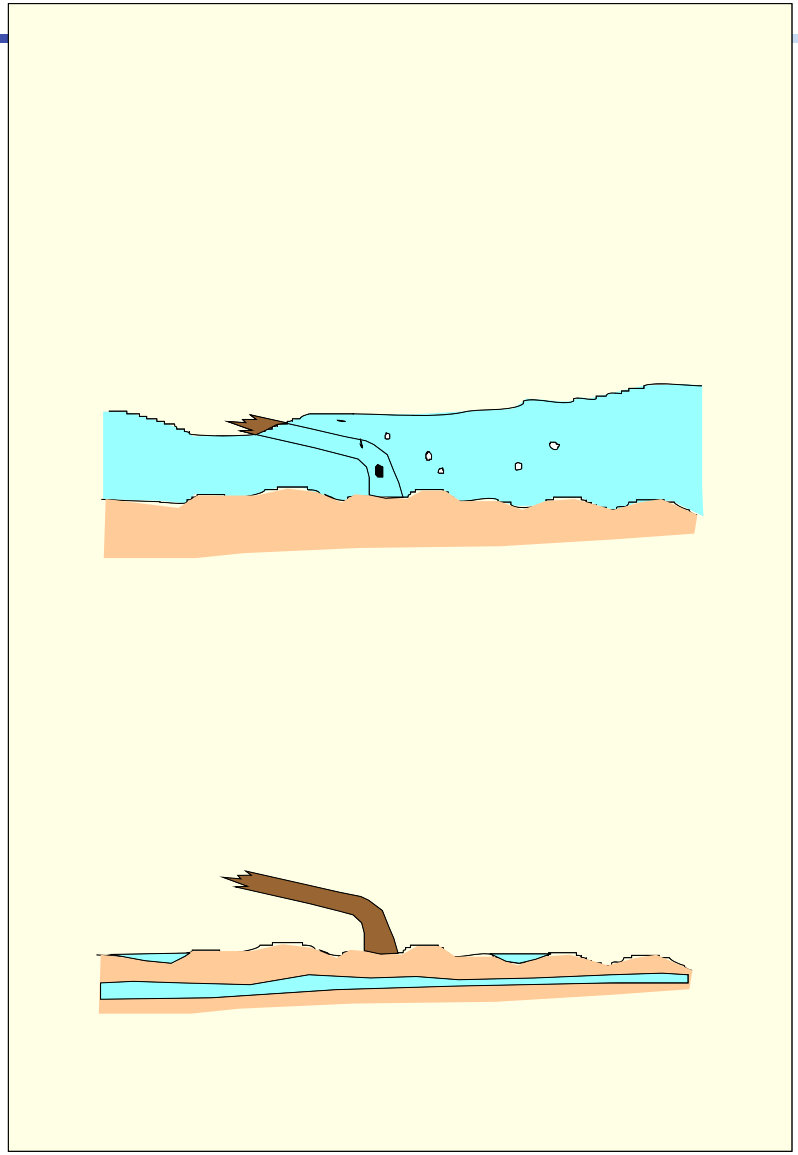

(Schweingruber, 2001)

Regular wood  Reaction wood

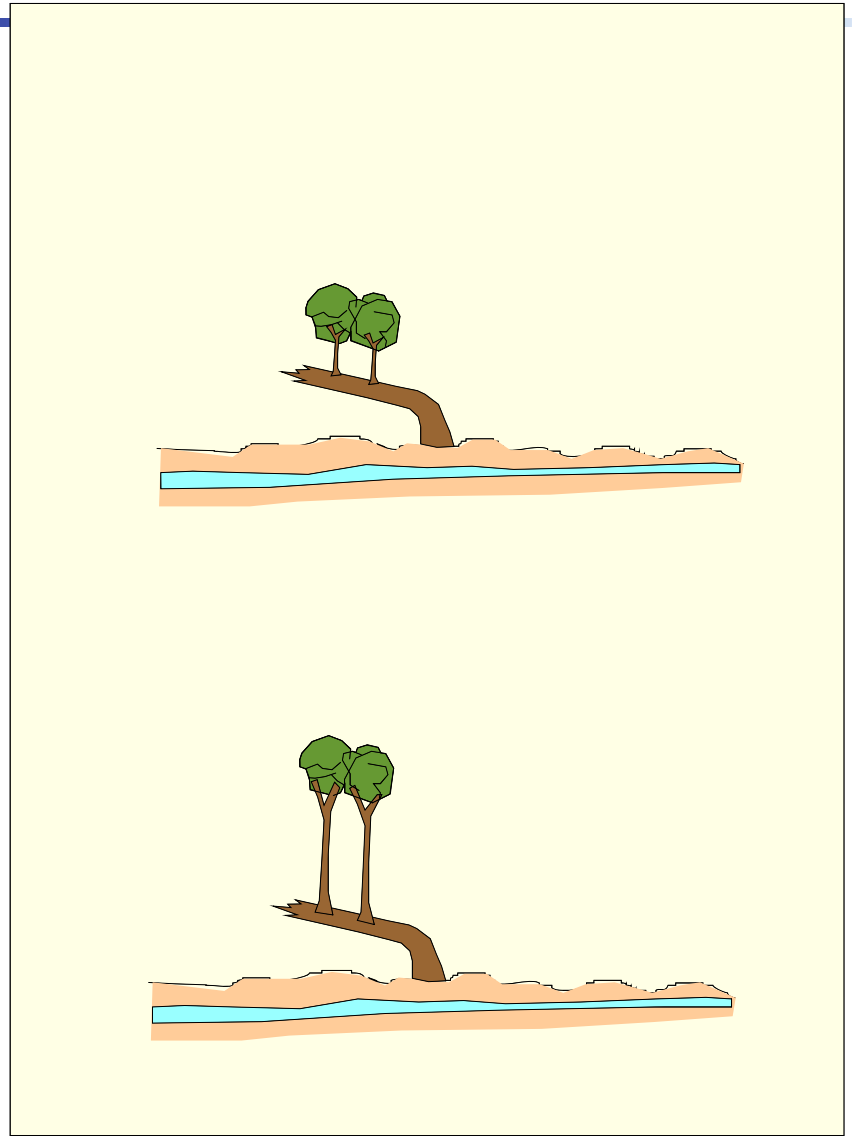
# Dendrogeomorphology



# Dendrogeomorphology

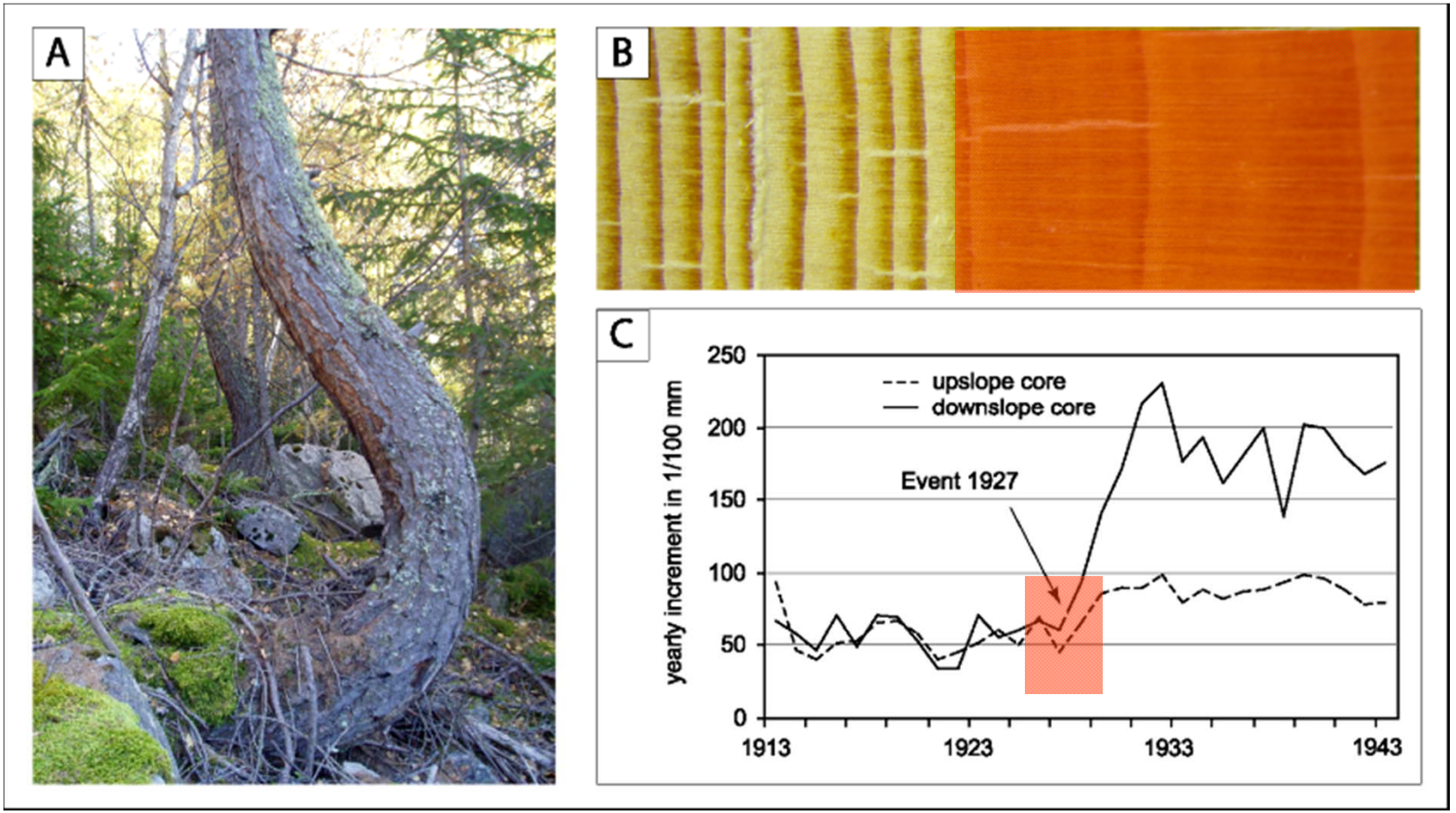


# Dendrogeomorphology



# Dendrogeomorphology

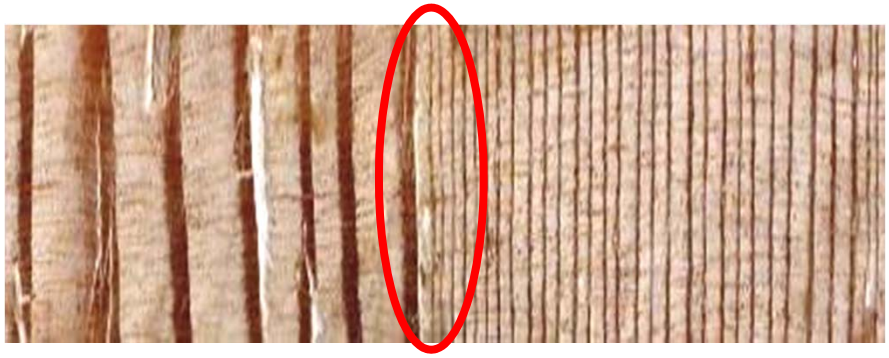
## *Stem tilting: eccentric growth and reaction wood*

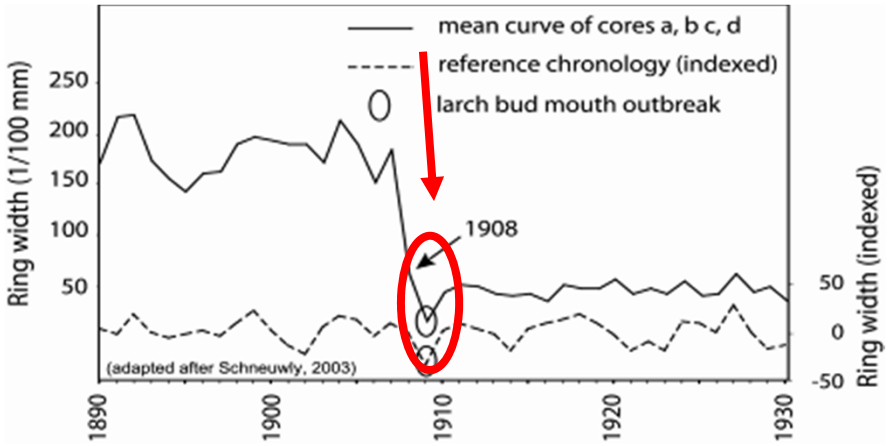



Bollschweiler, 2007, *GeoFocus* **21**

# Dendrogeomorphology

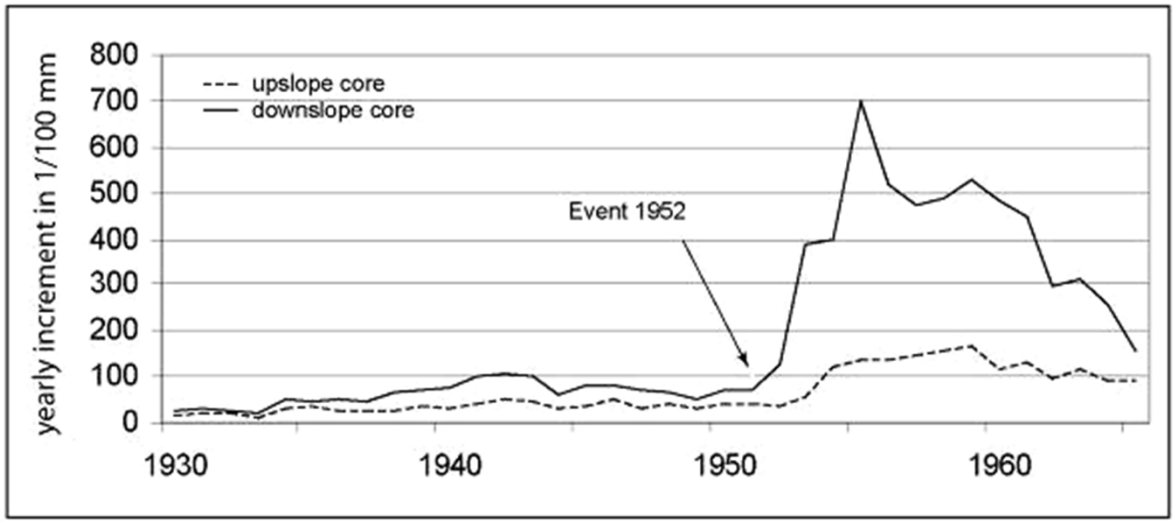
## *Decapitated trees*





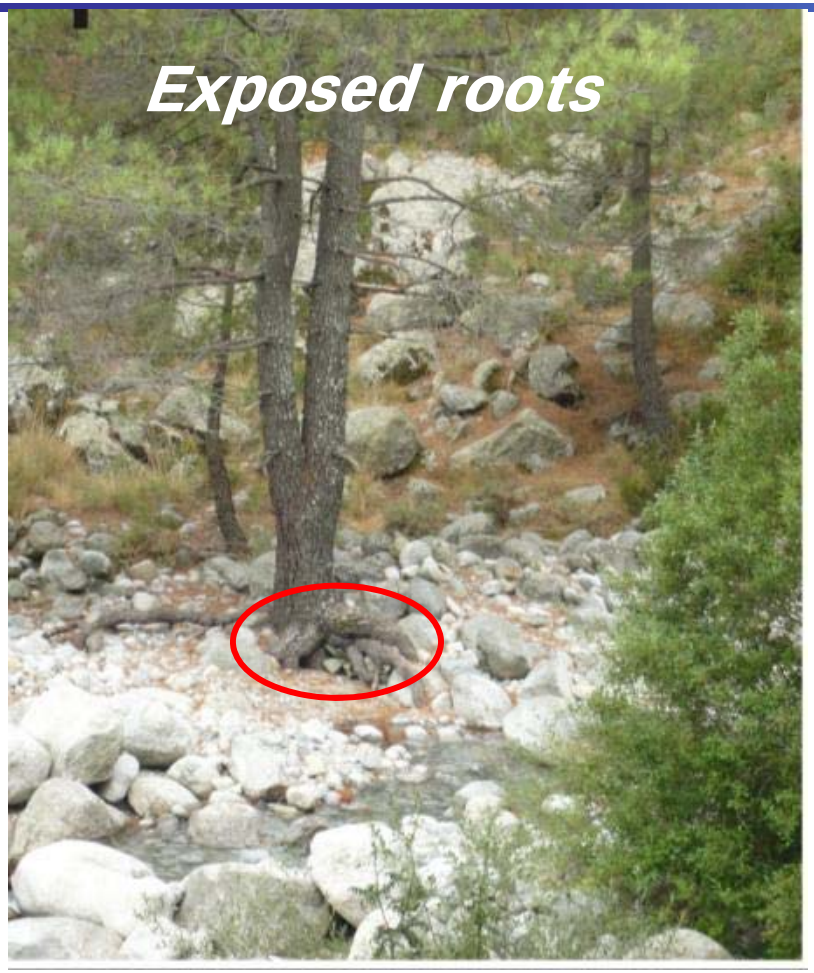

**Growth decrease!**

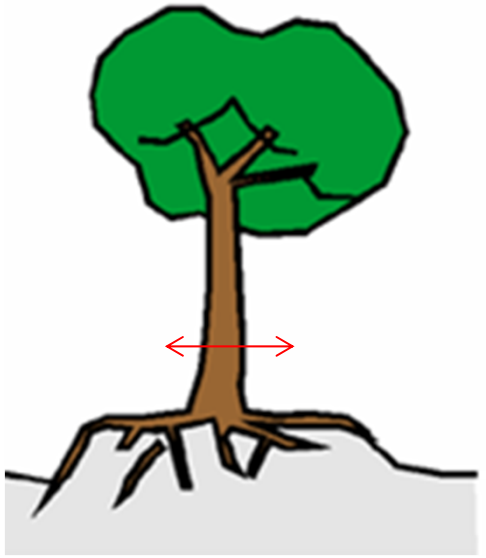
# Dendrogeomorphology

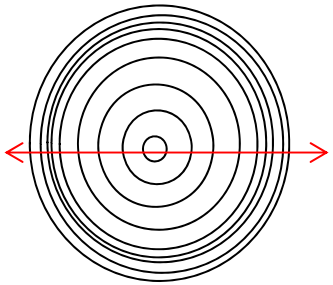



**Growth increase!**

# Dendrogeomorphology



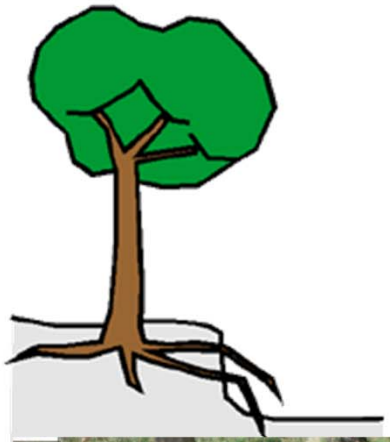





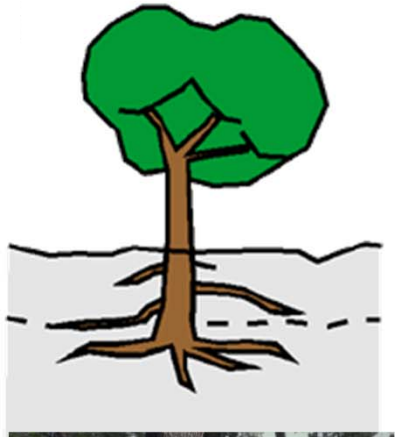
**Growth decrease!**

# Dendrogeomorphology

Totally exposed roots



Partially exposed roots



Adventitious roots

eccentric growth rings in roots

# Dendrogeomorphology

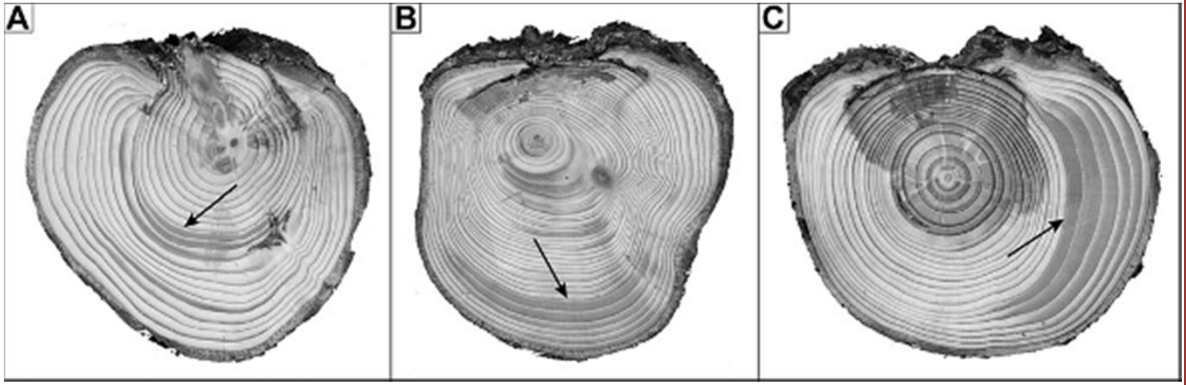
## *Microscopical scale*

- **DENDROGEOMORPHIC EVIDENCE**

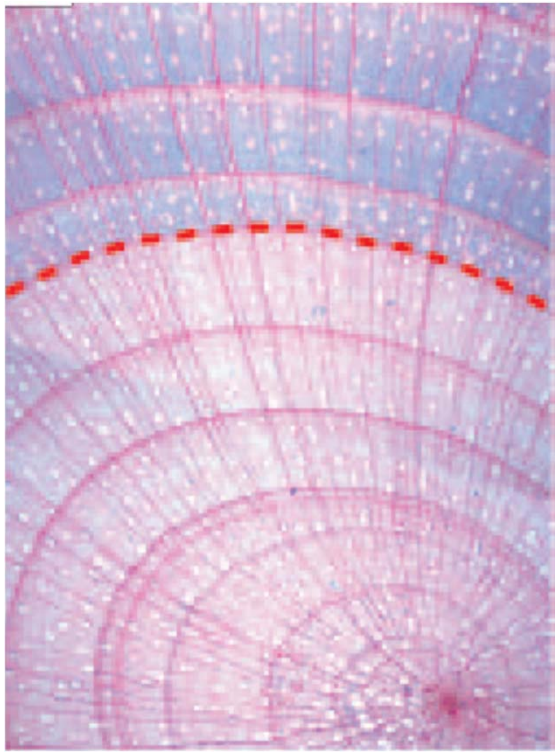
| | | | | | | |
|---|---|---|---|---|---|---|
| mm | Mesoscopic | Tissues, wedges and slices | Rings | Eccentric growths (reaction wood) | | ID 20 |
| | | | | False tree rings | | ID 21 |
| | | | | Discontinuities, erosion, and internal scars | | ID 22 |
| | | | Tissues | Changes in parameters (width, % early wood, late wood, etc) | | ID 23 |
| | Microscopic | Thin slice | | Ratio parenchyma-lignification tissue | | ID 24 |
| | | | | Size and density of vessels | | ID 25 |
| µm | | | Cells | Changes in cell parameters | Size and morphometry of lumen cells | ID 26 |
| | | | | | Cell wall thickness | ID 27 |
| | | | | Appearance and/or abundance of special types of cells | Traumatic resin ducts (TRDs) | ID 28 |
| | | | | | Fiber-tracheid | ID 29 |
| | | | | | Traumatic structures in cell wall | ID 30 |
| Å | Atomic | Cell wall | Cellulose | Isotopic fractionation | $^{18}O/^{16}O$ ratio | ID 31 |

# Dendrogeomorphology

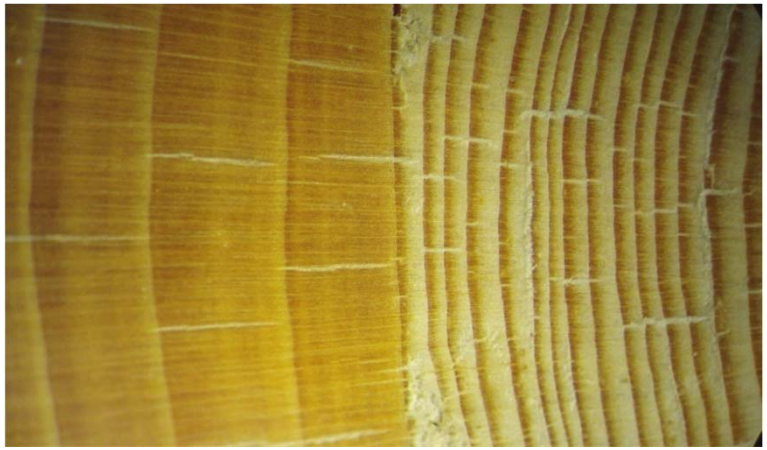
Reaction wood (tension wood) in *Acer pseudoplatanus* L. (Source: Hitz, 2008).




(SCHNEUWLY et al., 2009)

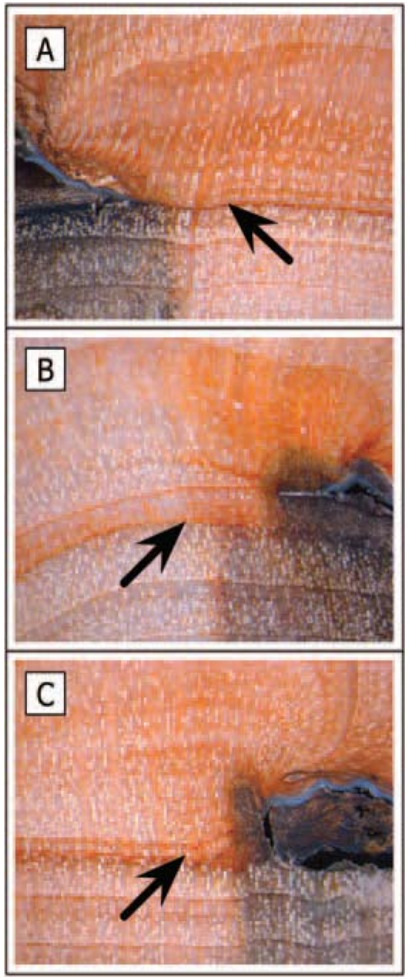


**Different kind of cells (more lignin (conifer trees) or mucilaginous (broadleaved trees)!**

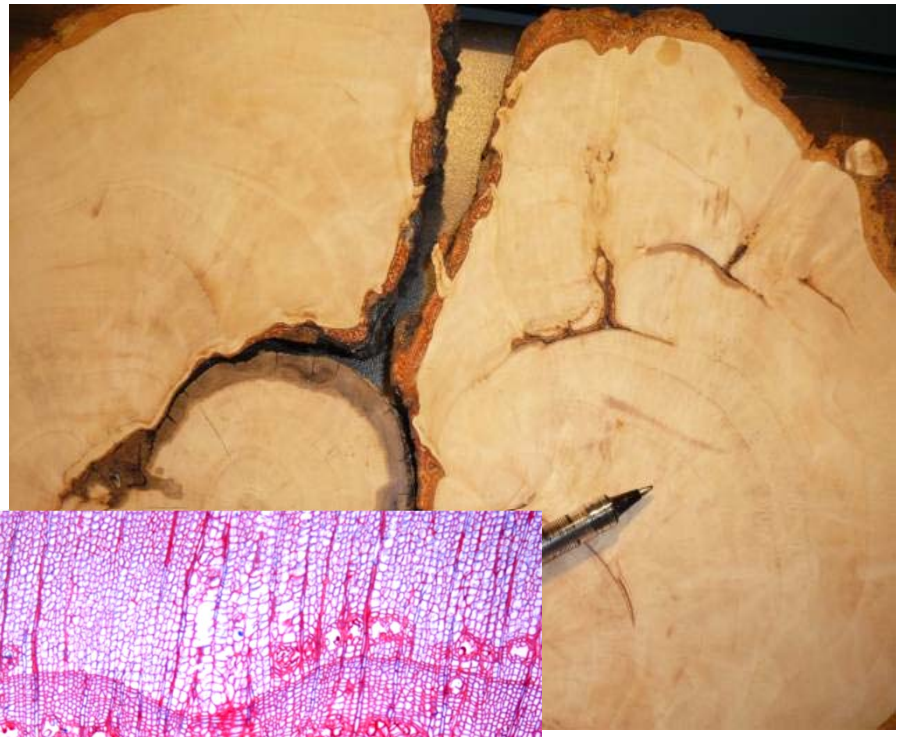


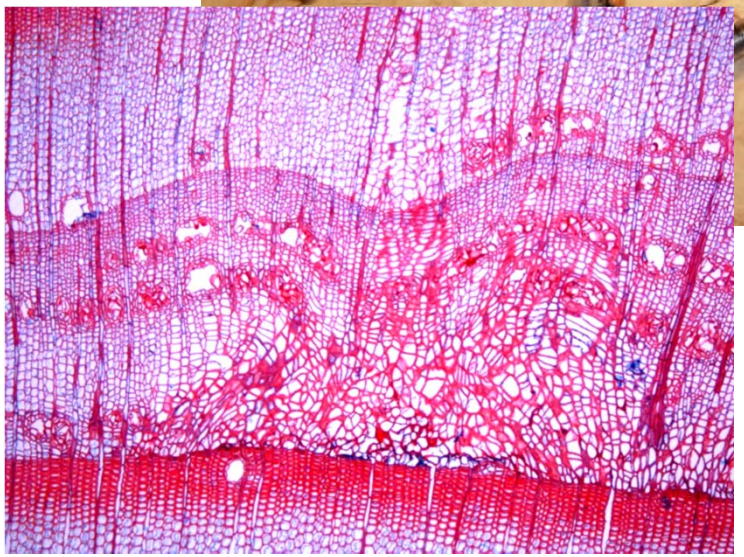
# Dendrogeomorphology

## *Anatomical features associated to scars in trees*



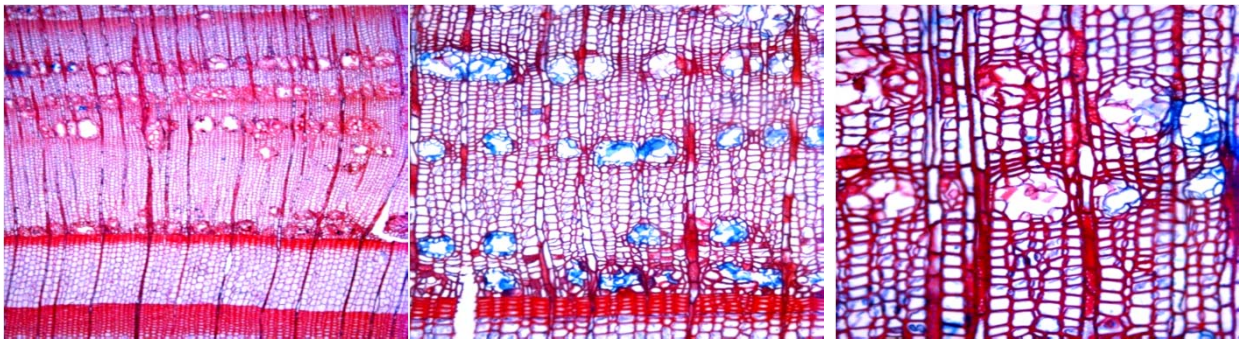

Arbellay et al., 2010

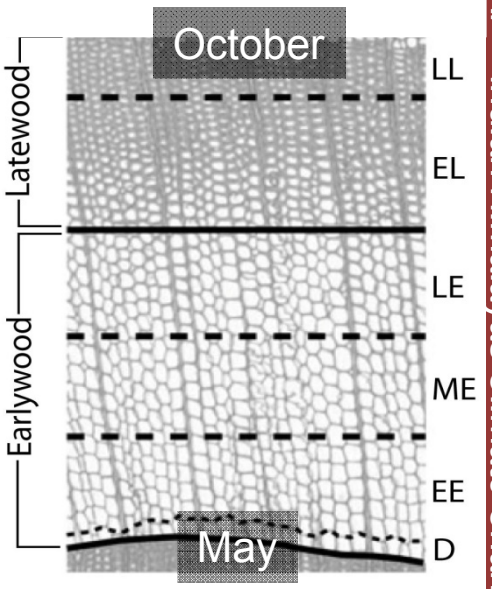




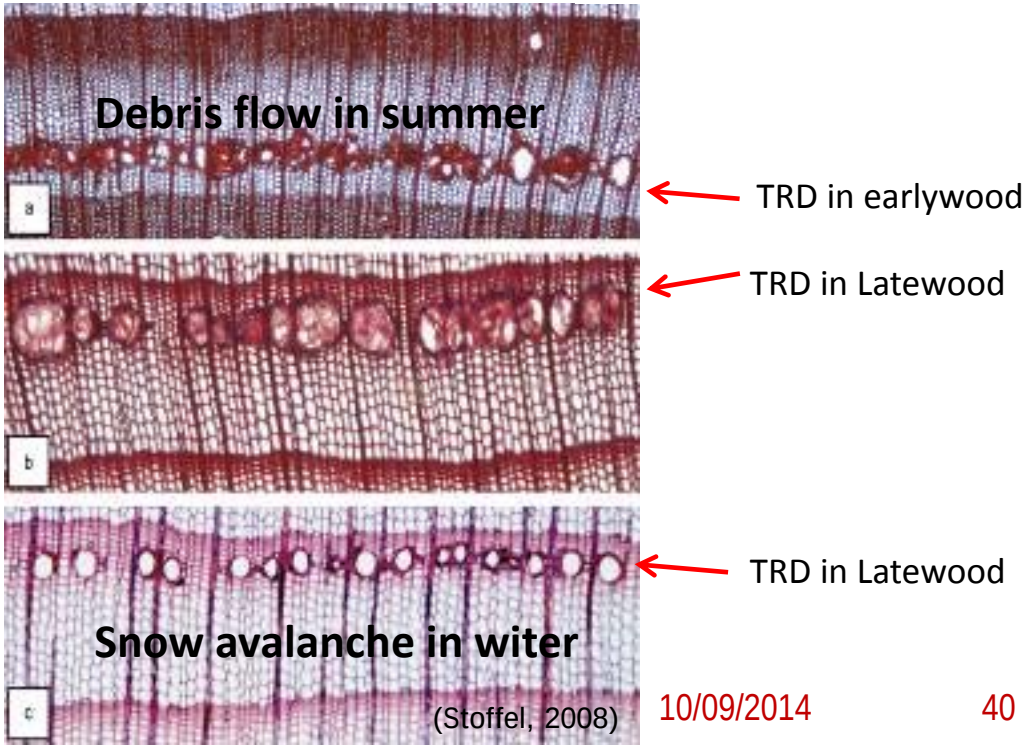
# Dendrogeomorphology

***Anatomical features associated to scars in trees***





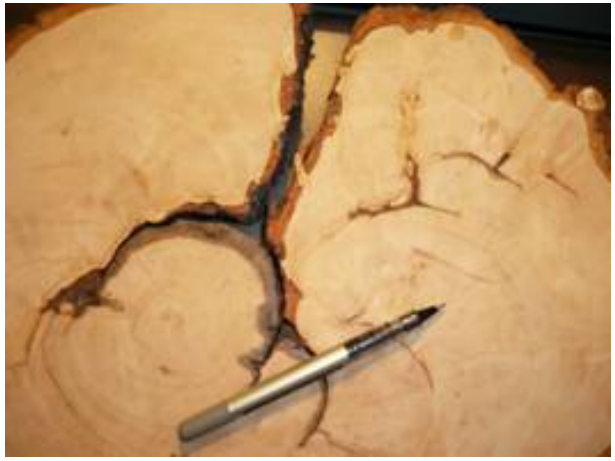

In some **conifers trees** (Larix, Picea or Abies): Tangential rows of **traumatic resin ducts (TRD)**



# BOTANICAL SOURCES

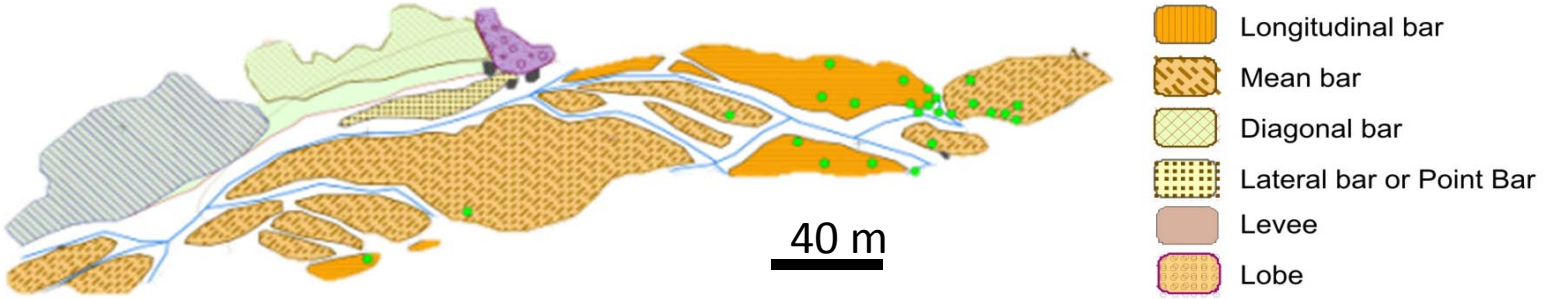
## Tree-rings:

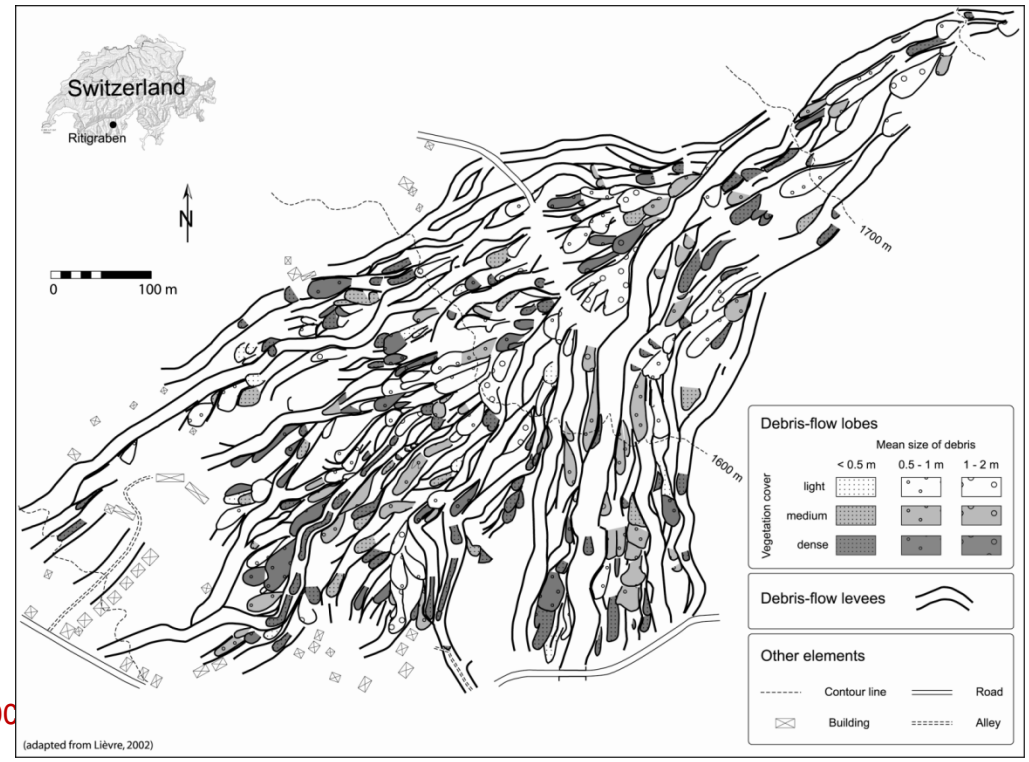
1. What is dendrochronology?
2. Application fields
3. Natural processes and tree rings: Dendrogeomorphology
6. Methodologies



# Dendrogeomorphology

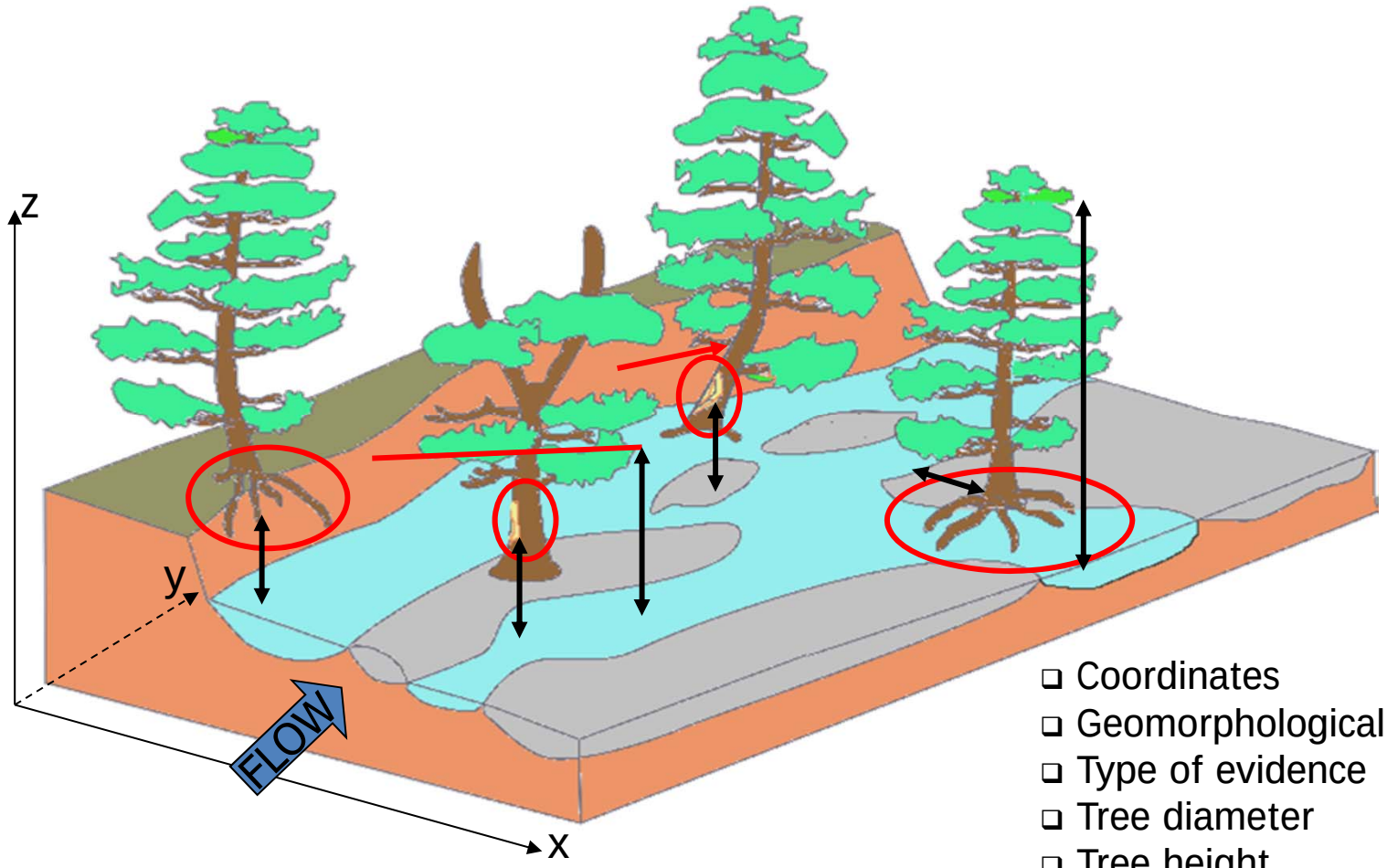
- **FIRST TASK: Geomorphic mapping**



# Dendrogeomorphology

- **SECOND TASK: Description of dendrogeomorphic evidence and sampling**

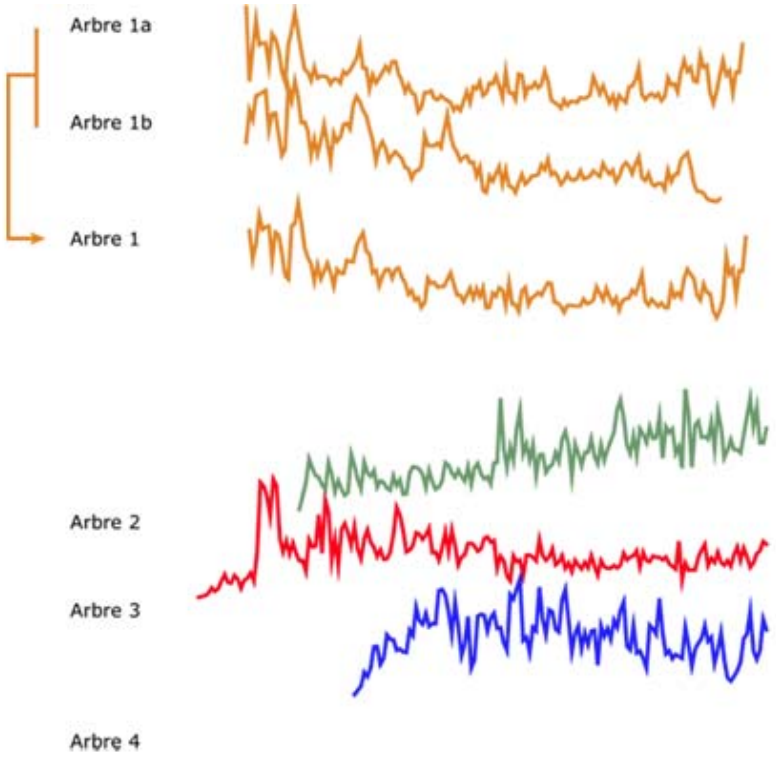



- Coordinates
- Geomorphological position
- Type of evidence
- Tree diameter
- Tree height
- Sampling position

# Dendrogeomorphology

# Dendrogeomorphology

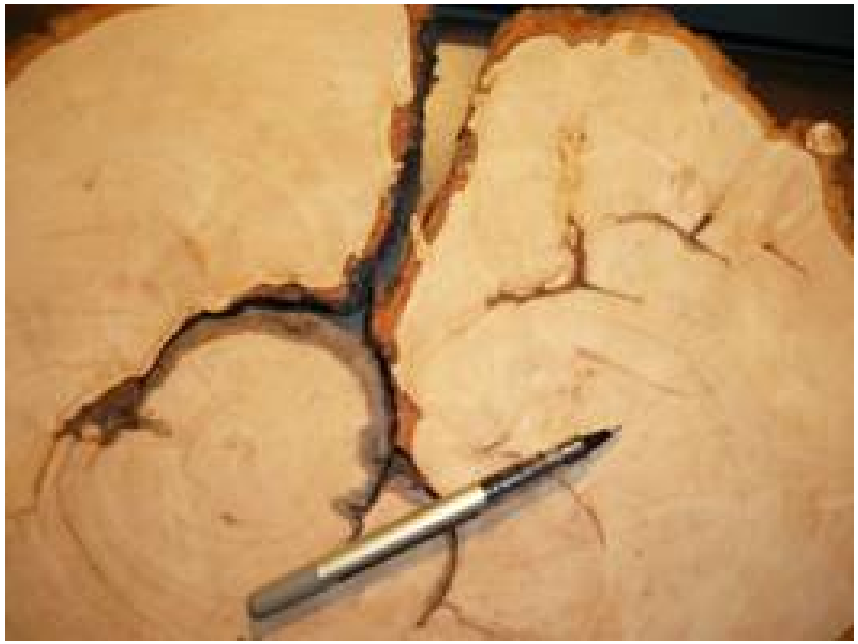
- The environmental signal being investigated (P, T, drought, …) can be maximized (and the amount of noise minimized) by sampling more than one core per tree and more than one tree per site.
- Replication is important to build a robust chronology.




# Dendrogeomorphology

- **SECOND TASK: … sampling**

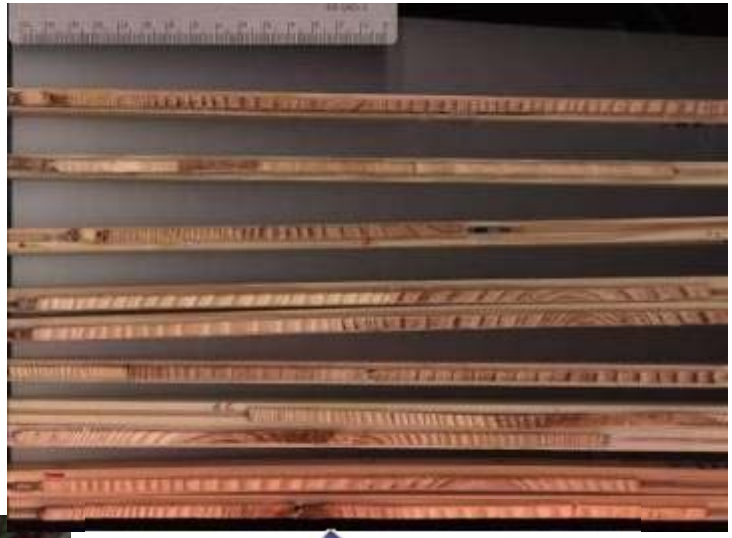
- **How to sample?**



# Dendrogeomorphology

- **SECOND TASK: … sampling**

- **How to sample?**



# Dendrogeomorphology

- **SECOND TASK: … sampling**
- **Where to sample?**

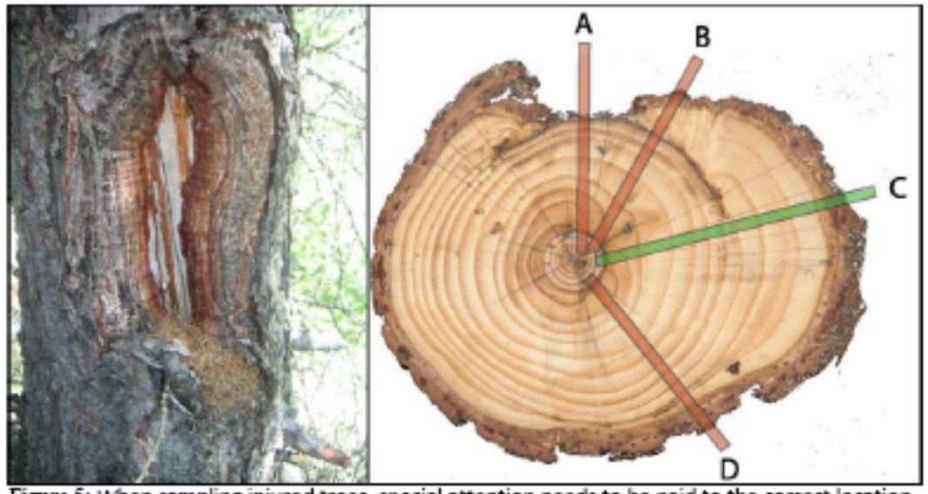



**Figure 5:** When sampling injured trees, special attention needs to be paid to the correct location. When extracting samples from the positions A or B, tree rings will be missing and a correct dating of the injury is not possible. The good position for the sampling would be position C where the injury just finishes and the overgrowing callus tissue and the bordering TRD start. In contrast, D is too far from the injury and no GD can be determined here.

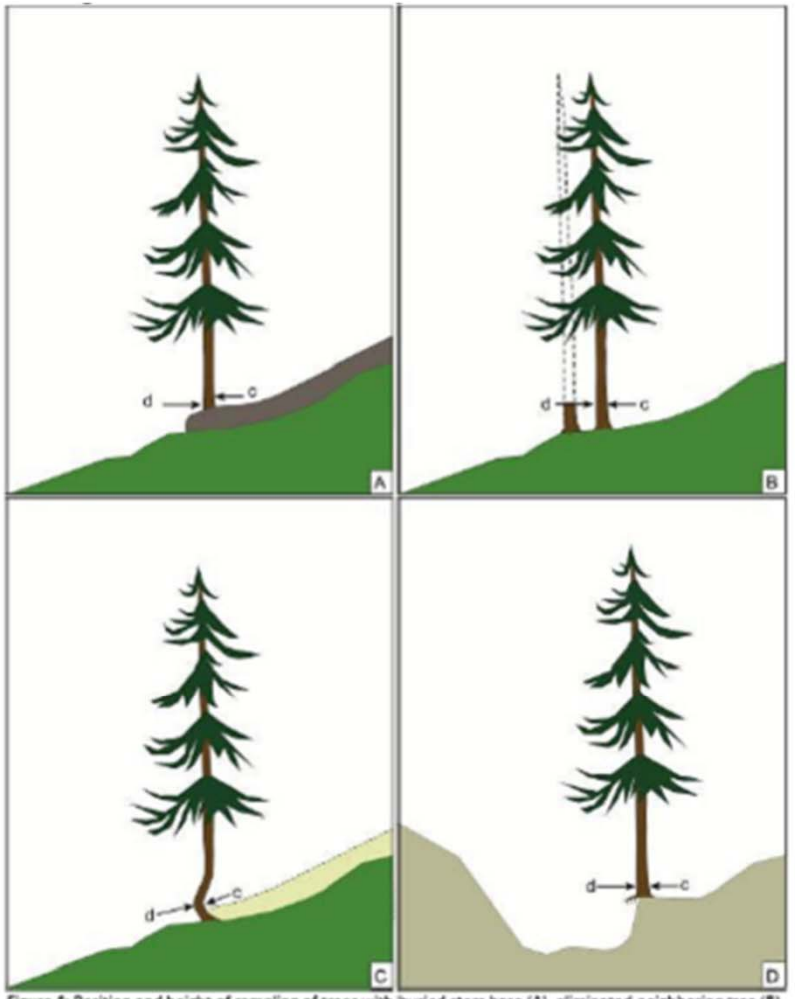
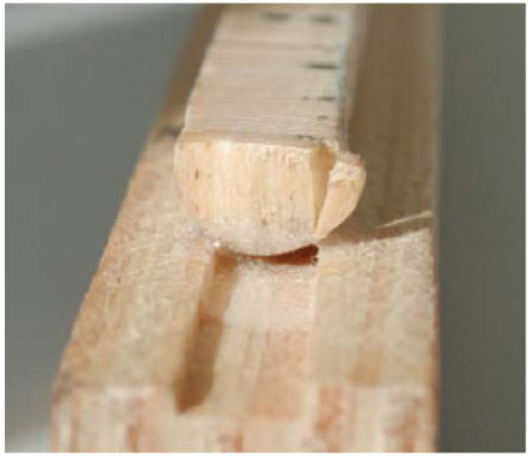



Figure 4: Position and height of sampling of trees with buried stem base (A), eliminated neighboring tree (B), tilted stem (C) or root erosion (D).

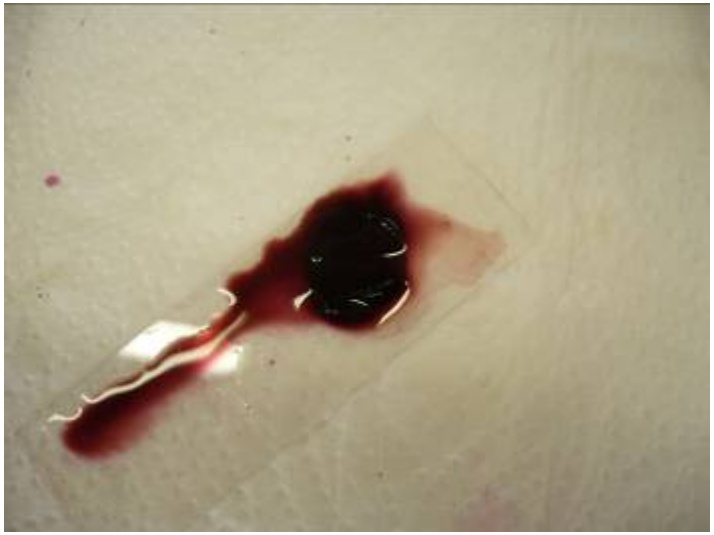
# Dendrogeomorphology

- **THIRD TASK: Sample preparation**



# Dendrogeomorphology

- **THIRD TASK: Sample preparation**



# Dendrogeomorphology

- **FOURTH TASK: Analysis of samples**

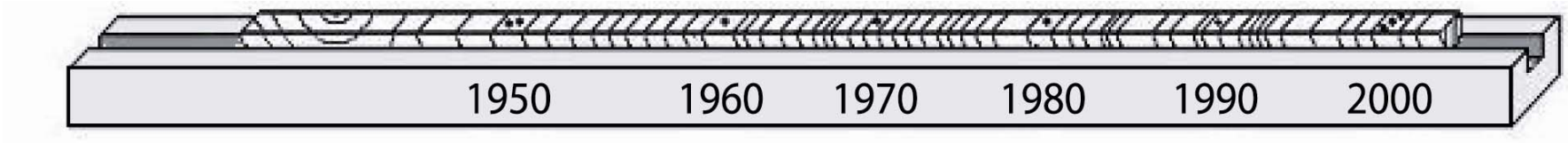
***Methods of analysis*** **Counting, measuring and crossdating**

1) **Subjective visual methods: SKELETON PLOTS**
2) **Statistical methods: TSAP, COFECHA**

# Dendrogeomorphology

- **FOURTH TASK: Analysis of samples**

Counting of tree rings



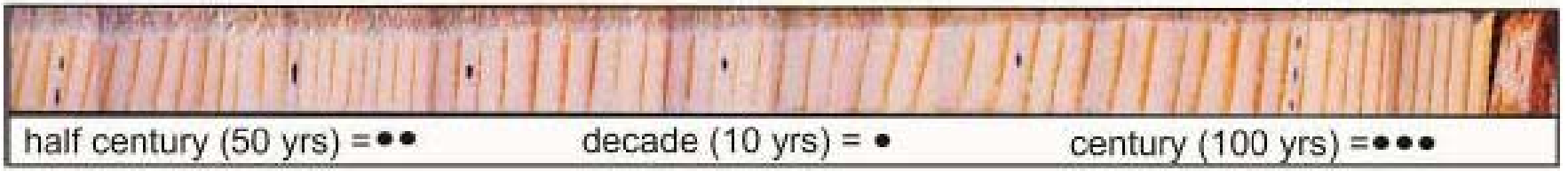




**Figure 6:** An example of a increment core of a *Picea abies* (L.) Karst each decade is indicated with one point, half-centuries with two points and centuries with three points

# Dendrogeomorphology

- **FOURTH TASK: Analysis of samples**

## Methods of analysis: Skeleton plots

**Legend for Skeleton Plot**

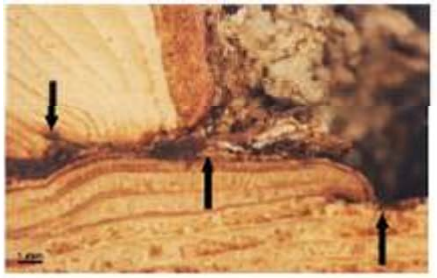
**Abbreviations**
S = scar
A = abrupt growth change (+ or -)
F = frost ring
R = radial crack
C = compression wood
T = traumatic resin canal (resin duct)
E = early wood
L = late wood
( ) = other side of pith

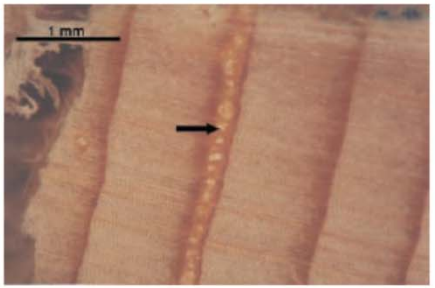
**Notation**
✱ = an event
○ = date of establishment – a dashed circle indicates an estimate due to stem burial
↔ = over the circle indicates an estimate
● = date of pith – actual if skeleton plot line solid, estimated if line dashed
□ = date of end of core or wedge
←□ = core or wedge continues, establishment date not estimated

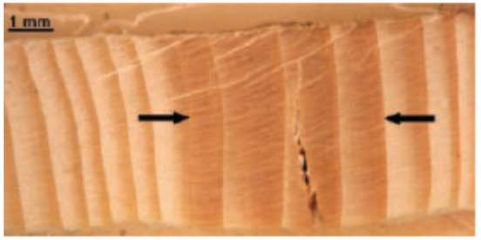
**Visual Growth Analysis**
Growth reductions (shown below the tree plot line with a "–A"):
- slight = 40–55%
- moderate = 56–70%
- strong = >71%

Growth increase (shown above the tree plot line with a "+A"):
- slight = 50–100%
- moderate = 101–200%
- strong = > 201%

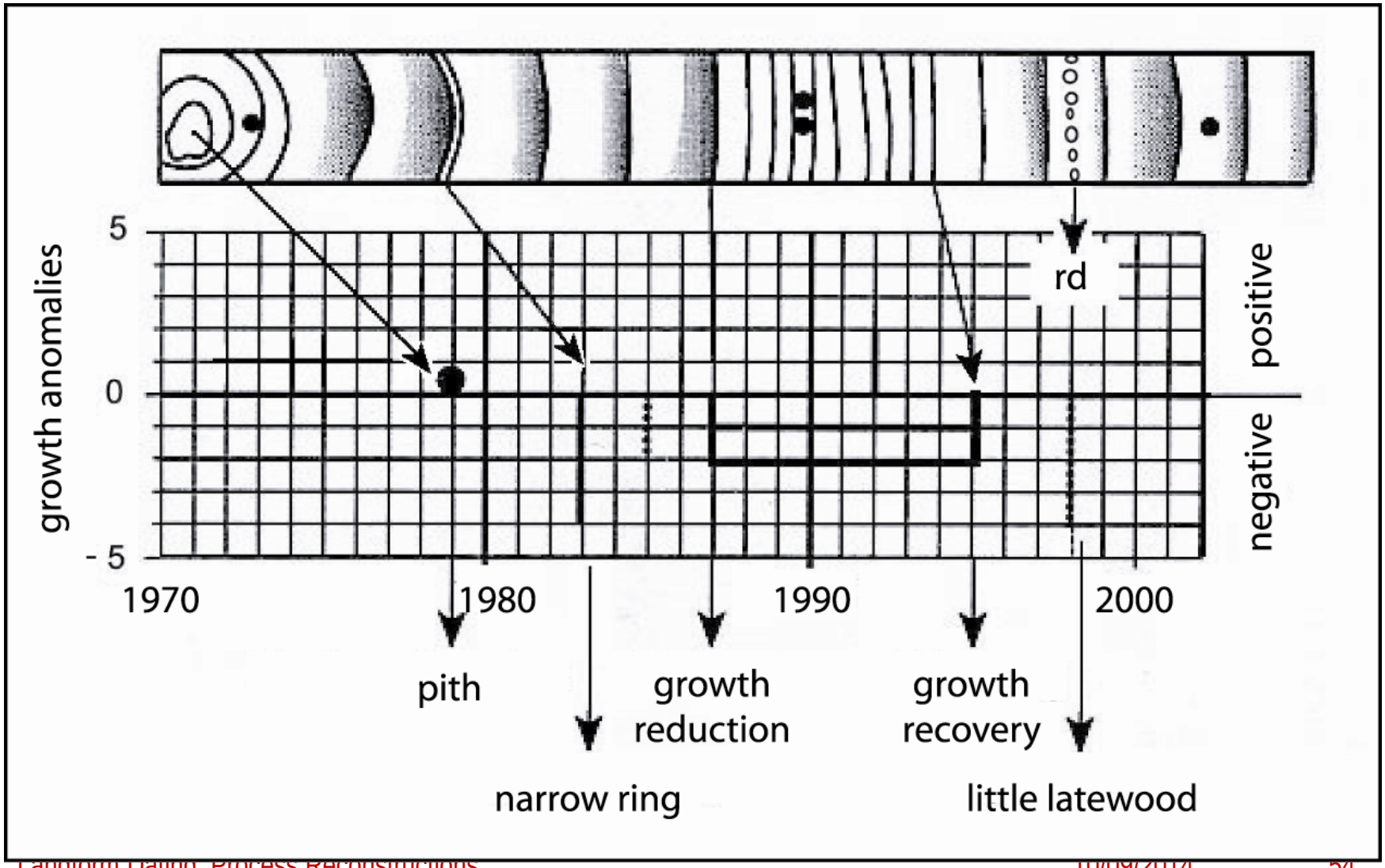
In cases where growth changes are gradual, two approaches are used in the skeleton plots:
↦ "release" / "suppression" indicates a gradual change starting at that point. This is used in cases where the growth is in long-term change due most likely to a change in stand conditions.
a dashed diagonal line from the start of change to the point where growth has changed enough to achieve the required ring width. This is used in cases where growth change is gradual, but most likely due to a hydrogeomorphic event—the tree generally returns to normal growth after a period of time.






# Dendrogeomorphology



# Dendrogeomorphology

## *SKELETON PLOTS*

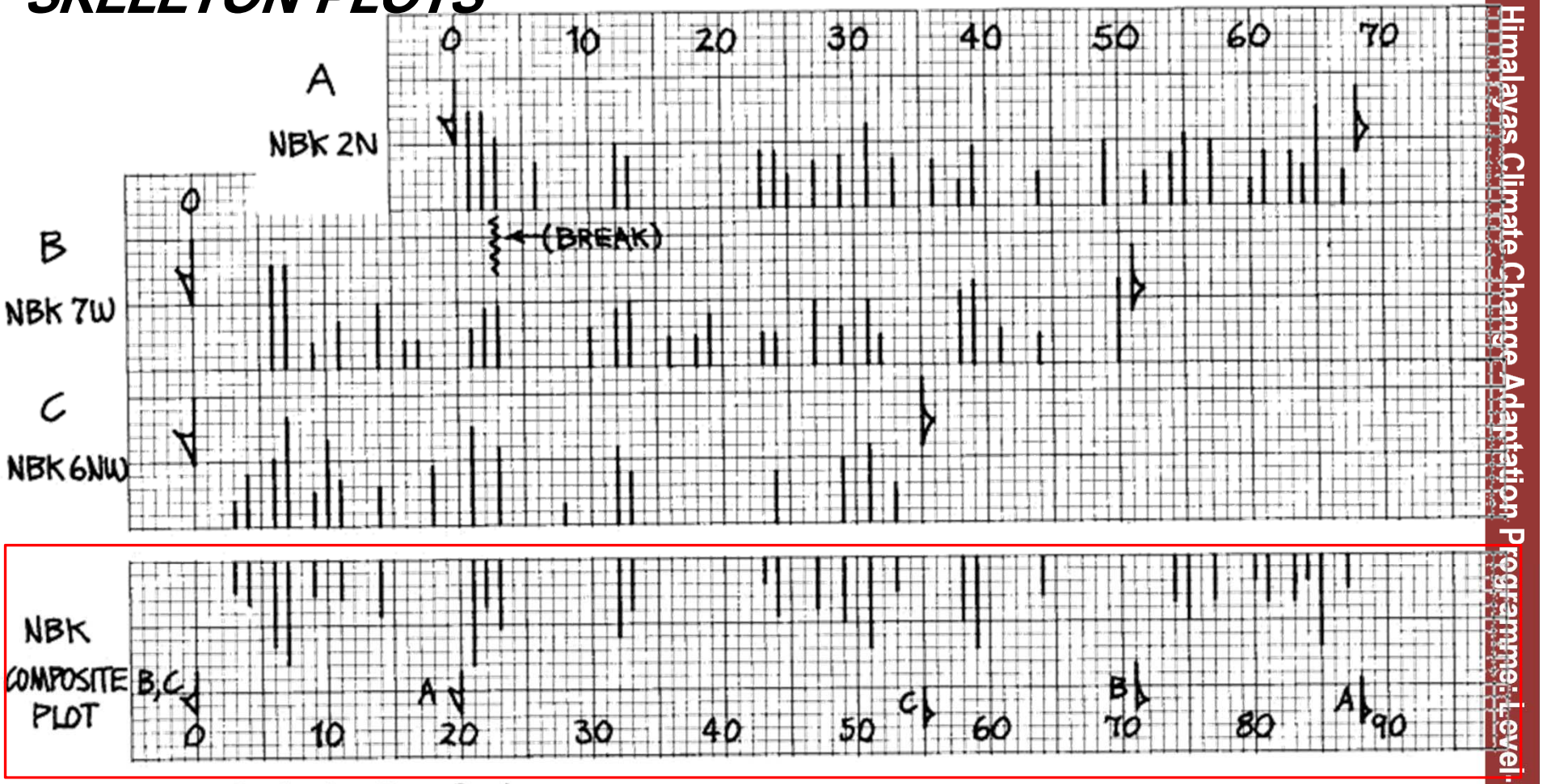
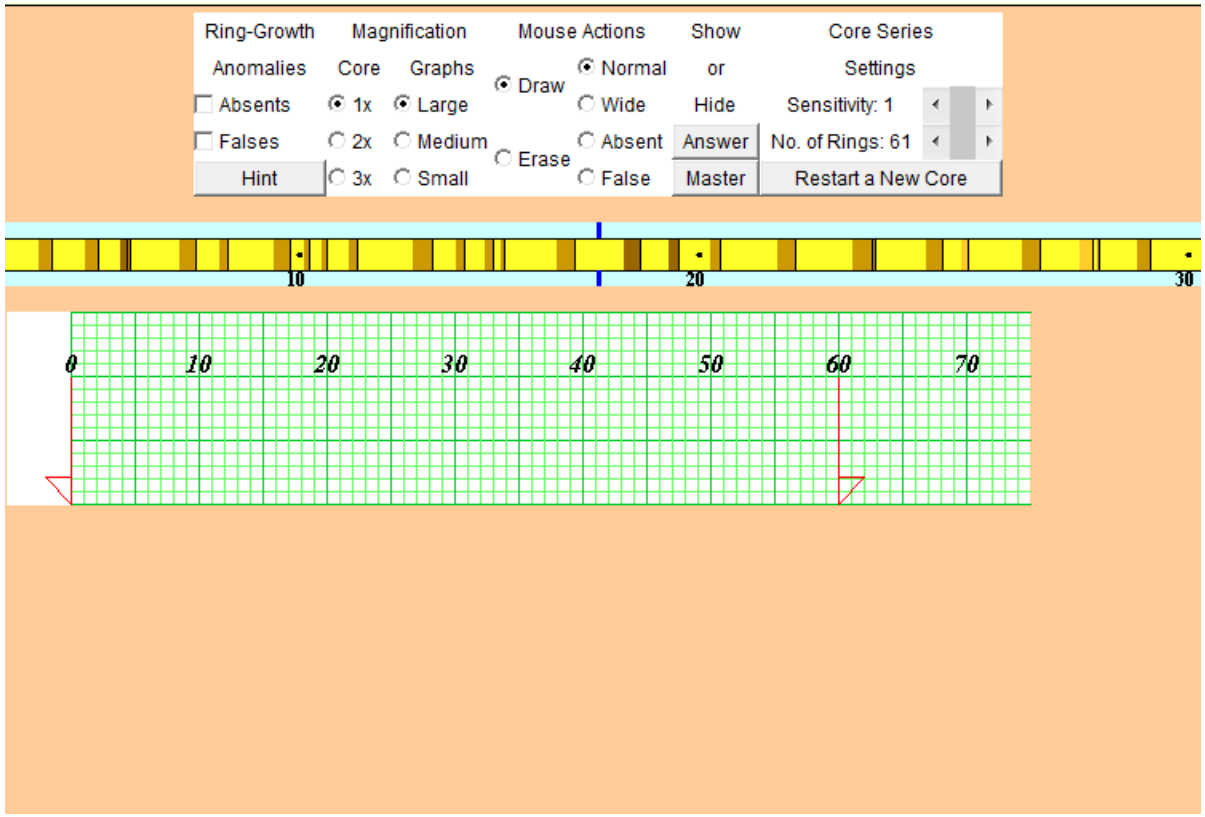



**Figure 12**—Skeleton plots for three Nancy Brook (NBK) cores and composite plot.

# Dendrogeomorphology

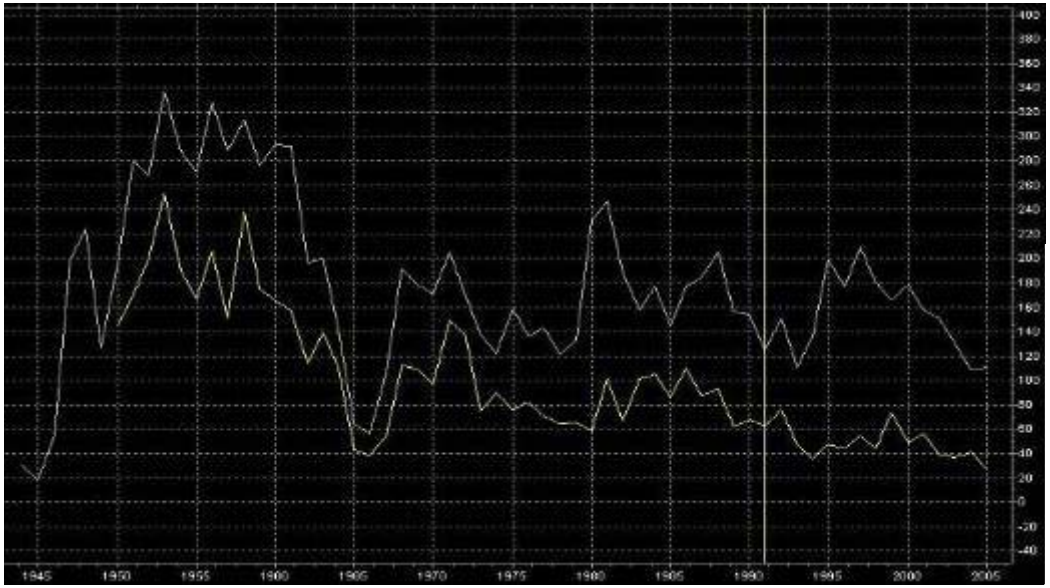
*Paul R. Sheppard*
*Laboratory of Tree-Ring Research, The University of Arizona*
URL: http://tree.ltrr.arizona.edu/skeletonplot/SkeletonPlot19.htm

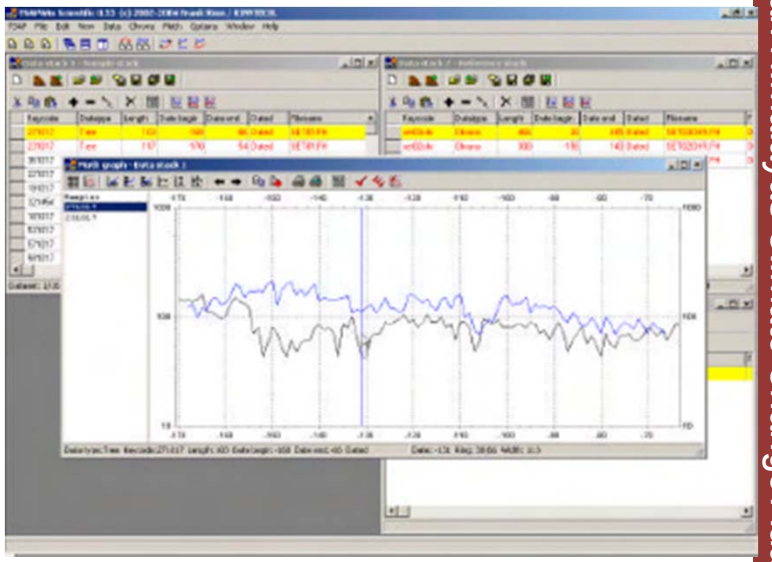


# Dendrogeomorphology

- **FOURTH TASK: Analysis of samples**

Methods of analysis: **Measuring devices & statistical methods**

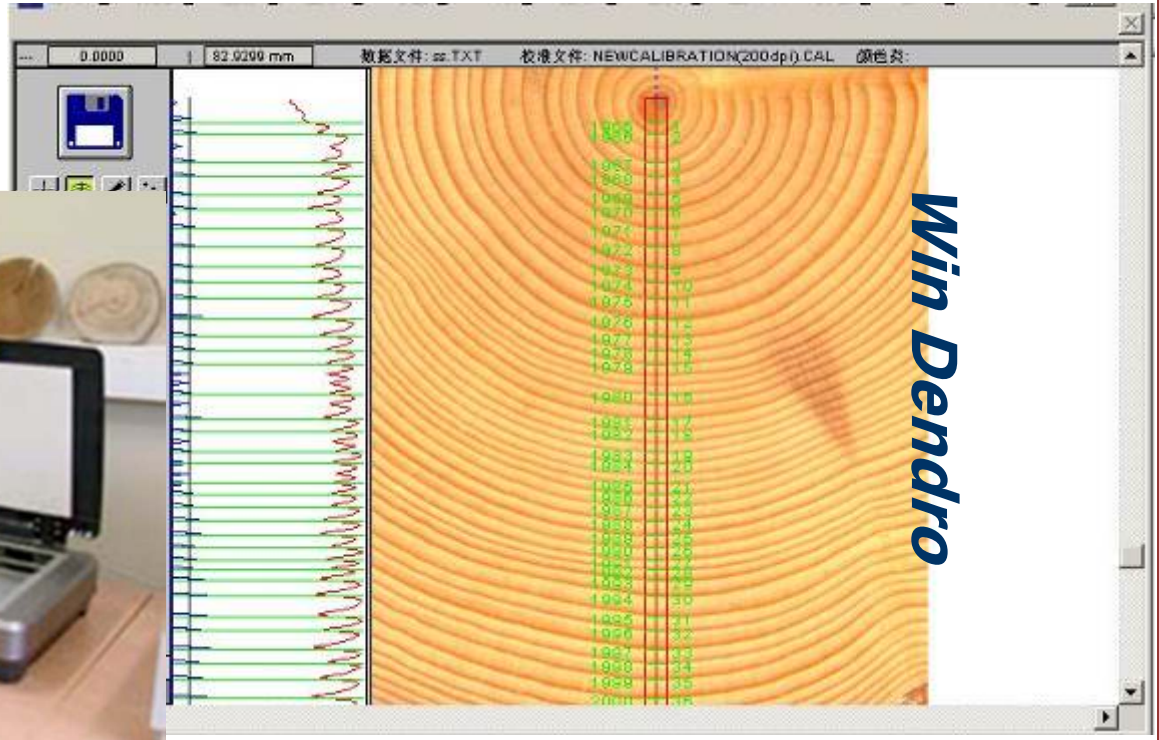




# Dendrogeomorphology

- **FOURTH TASK: Analysis of samples**

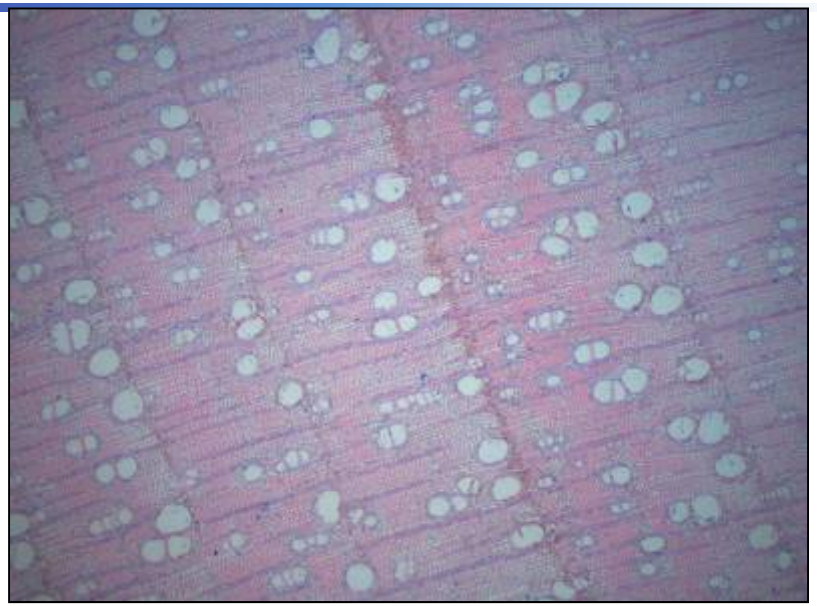
Methods of analysis: **Automatic measuring devices & statistical methods**



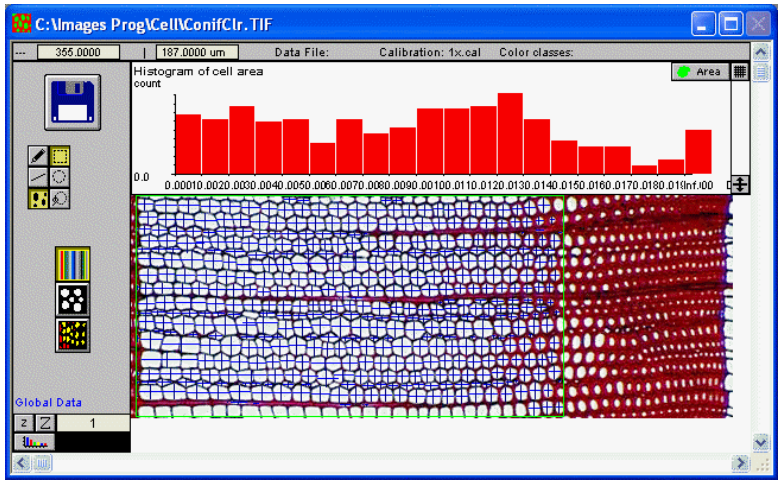
# Dendrogeomorphology

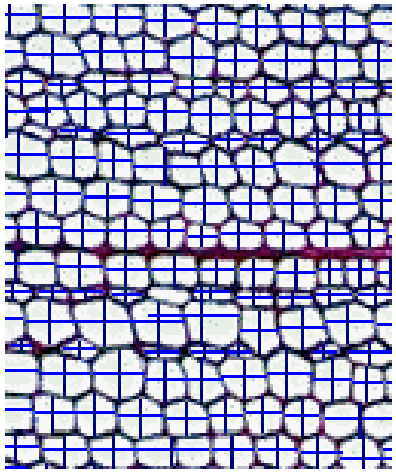
- **FOURTH TASK: Analysis of samples**

- **Methods of analysis: anatomical procedures and biometric automated measurements**



***Wincell***



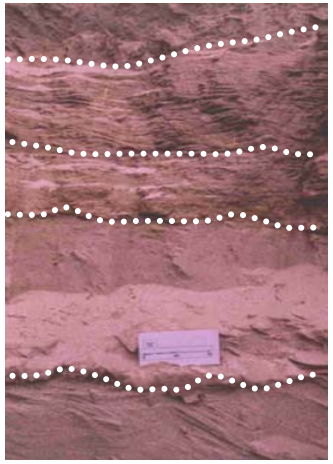
*II. Historical proxies*

*III. Biological proxies*

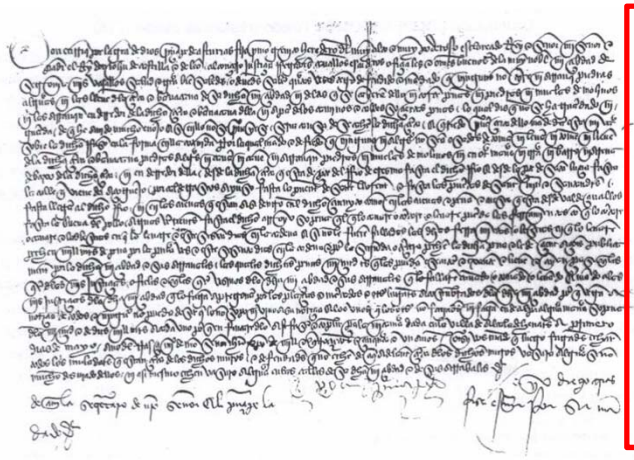
*I. Geological and geomorphic proxies*

***Thousands years BP***

***5th Cent.*** ***10th Cent.*** ***15th Cent*** ***20th Cent***



Facies



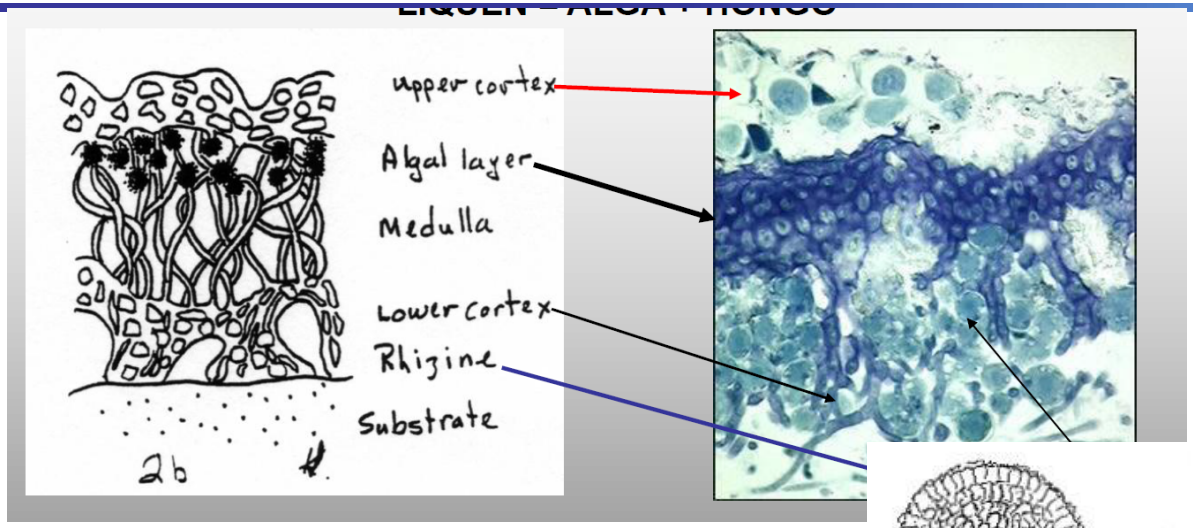
Documentary sources

Tree rings and lichens

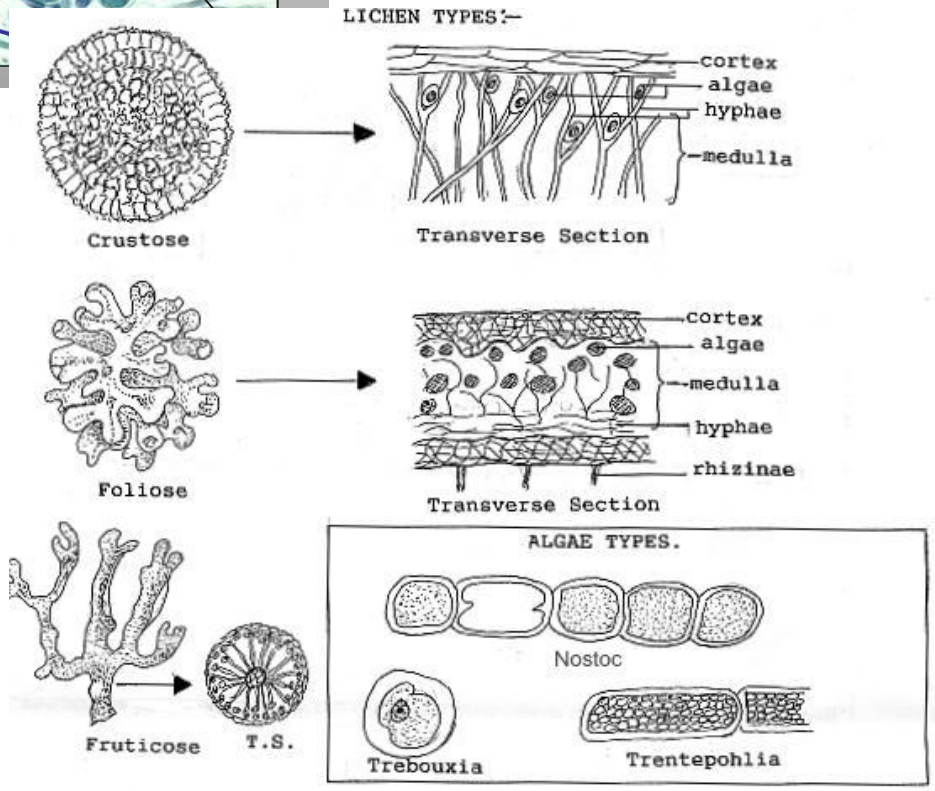
# Lichenometry

- What is a lichen? Some types…
- Methodology
- Applications

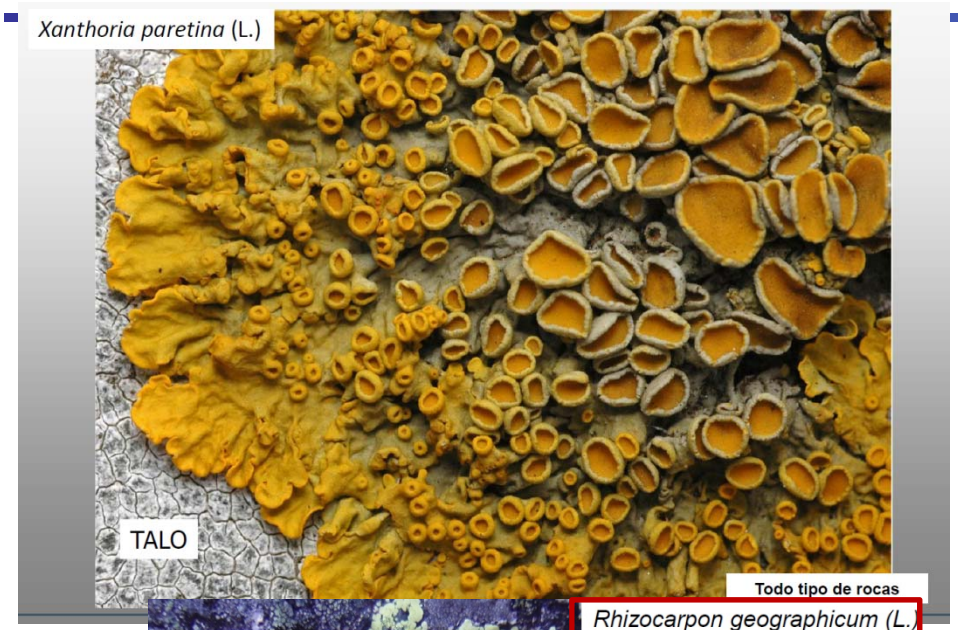
# Lichenometry

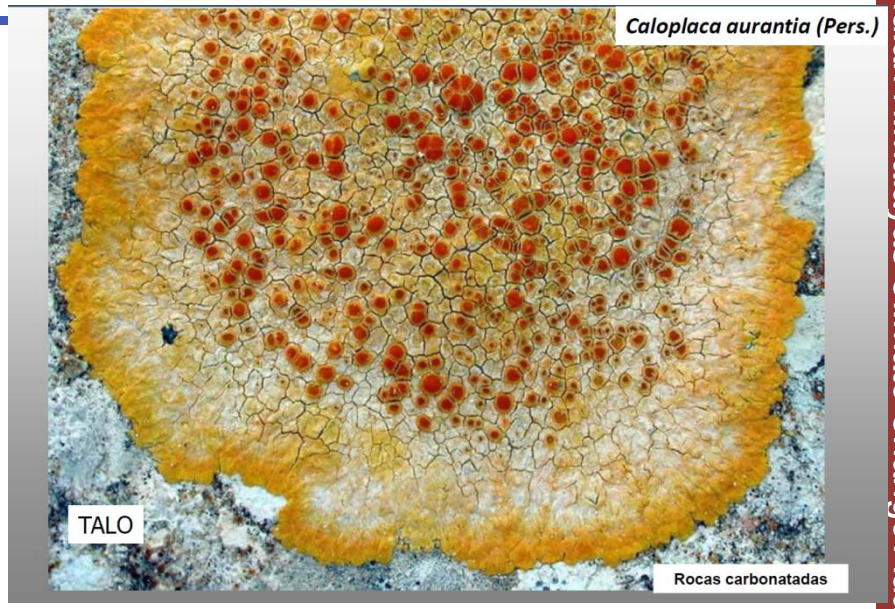


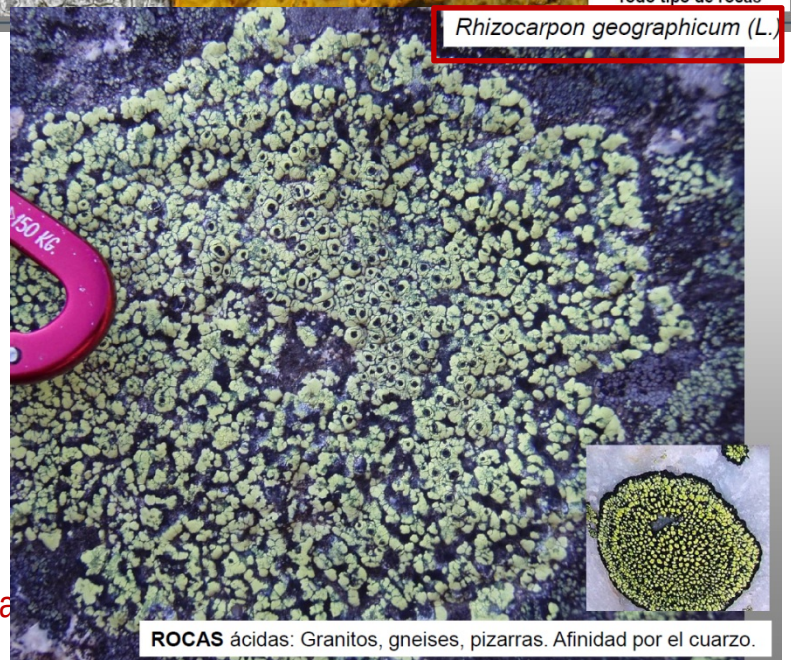

composite organisms consisting of a **fungus** and a photosynthetic partner (**algae**) growing together in a symbiotic relationship.

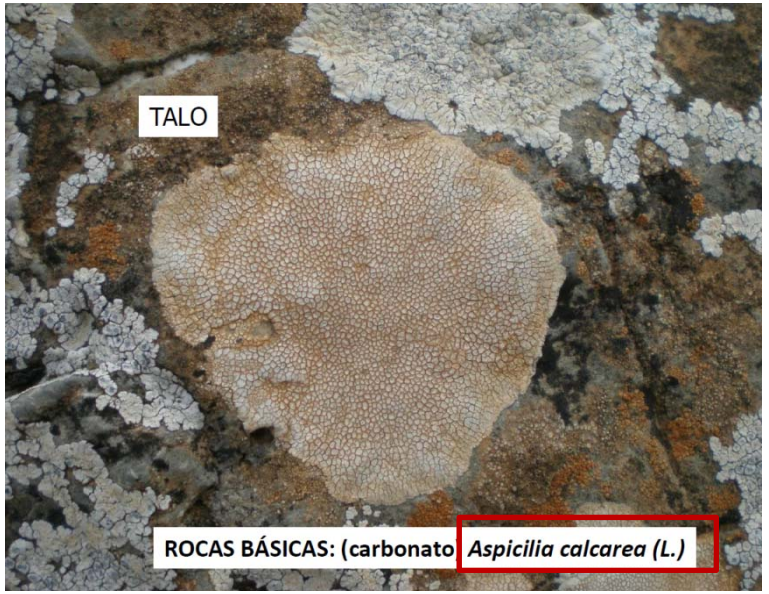


# Lichenometry



# Lichenometry

- What is a lichen? Some types…
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# Lichenometry

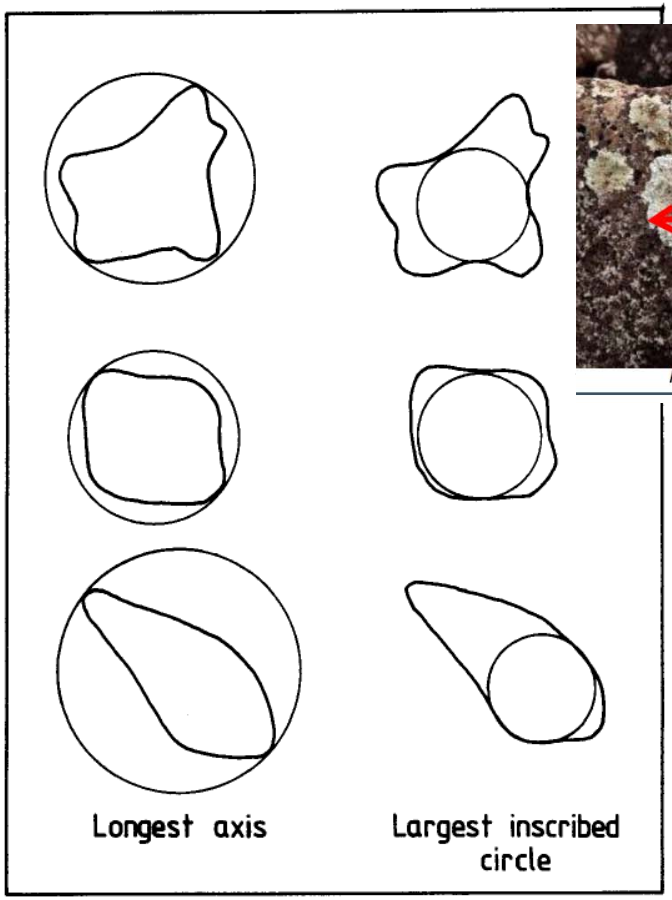
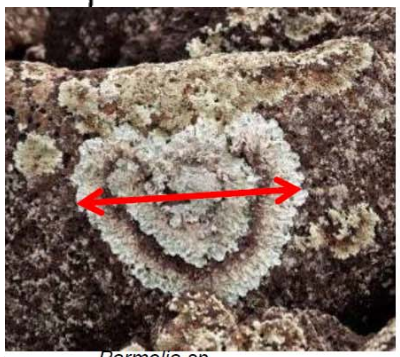
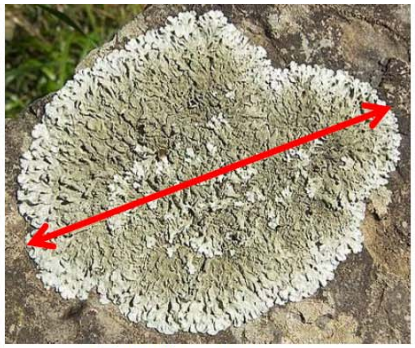



FIG. 1. Methods for measuring a lichen thallus: longest axis and largest inscribed circle.

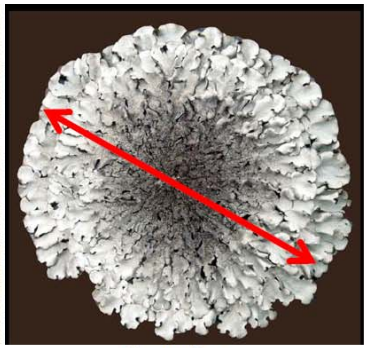
Innes, 1986



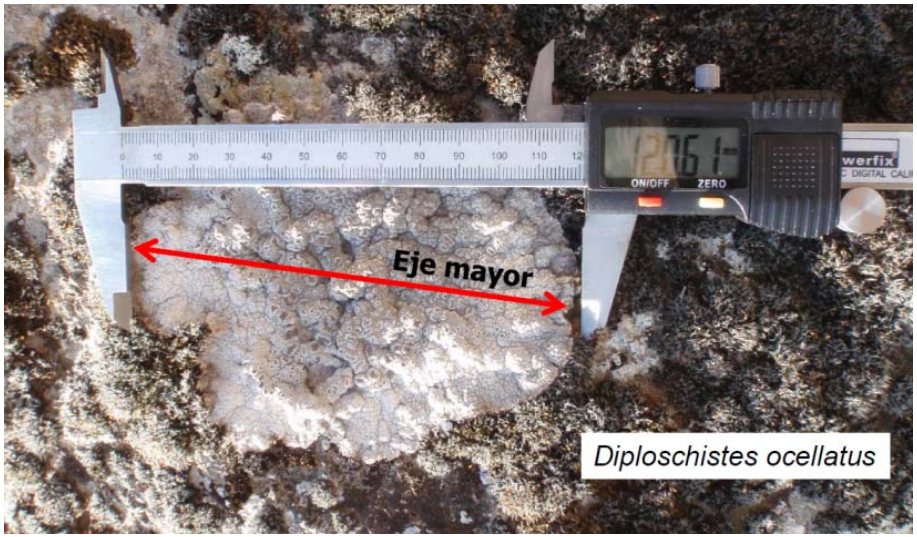
*Parmelia sp*



*Parmelia conspersa*



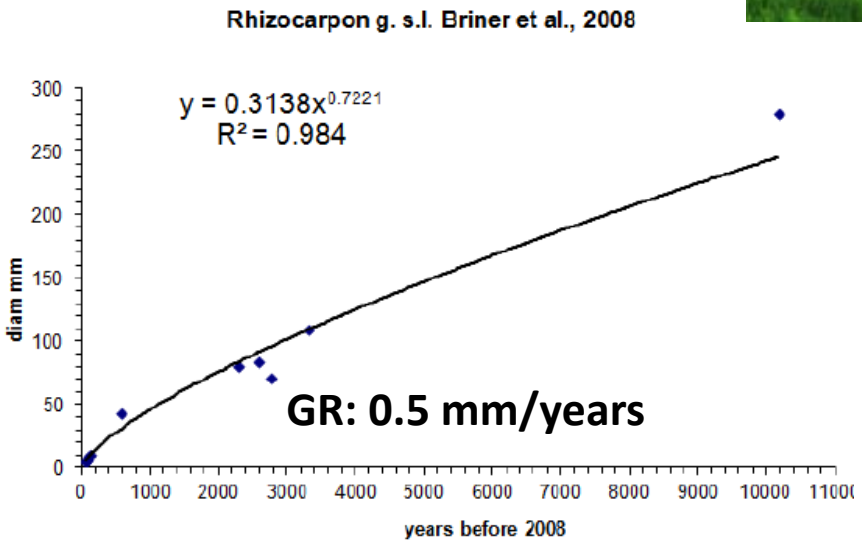
*Parmelia sp*

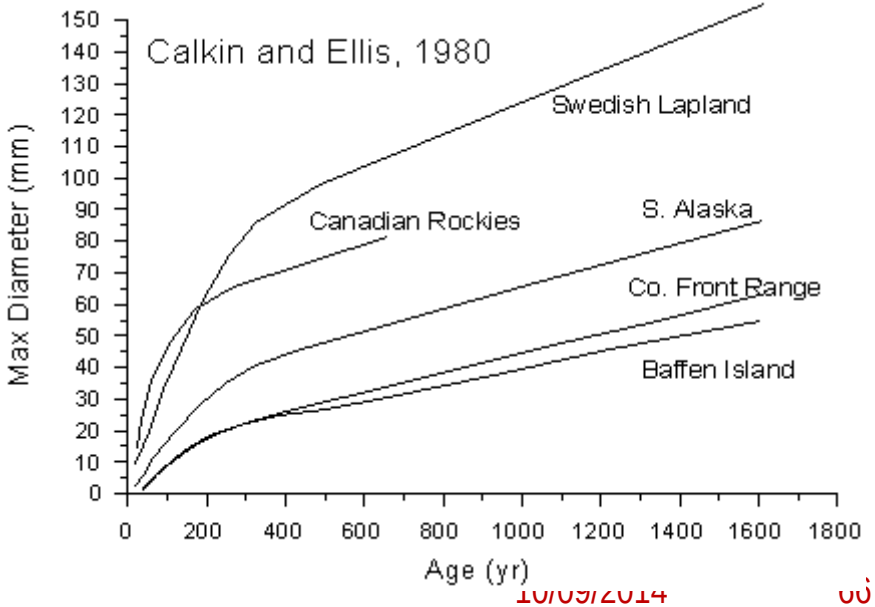



Longest inscribed circle and longest axis

# Lichenometry

(photo: Jomelli)



# Lichenometry

- What is a lichen? Some types…
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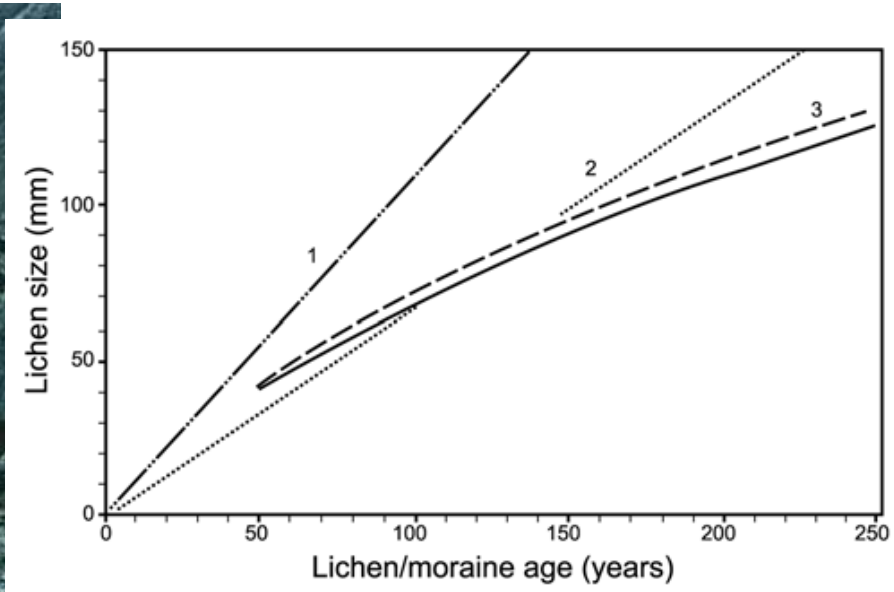
- Applications

# Lichenometry

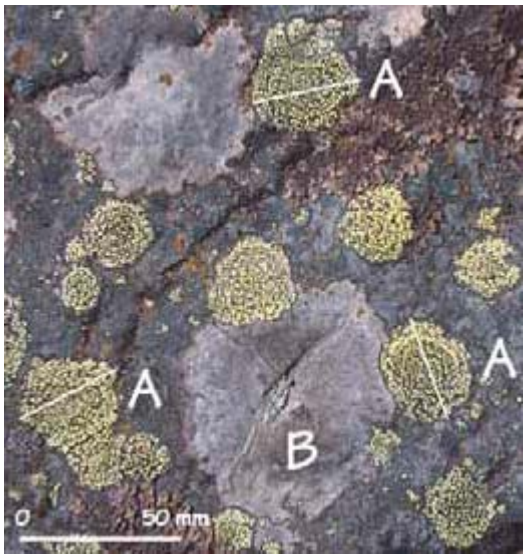
**The application of lichenometry in dating of glacier deposits**

*Boulders with lichen vegetation on a moraine ridge in the glacier foreland at the Mittivakkat Glacier*

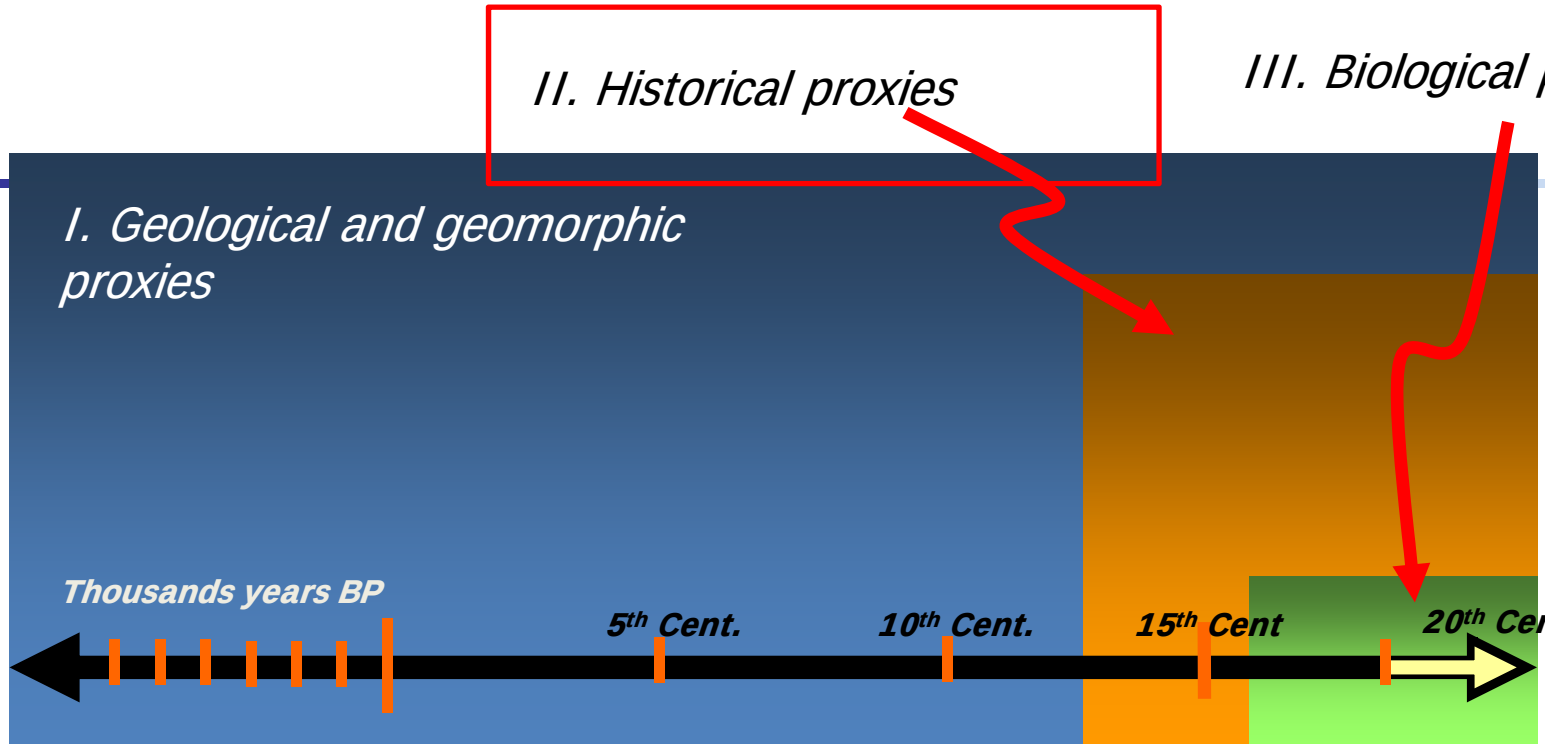


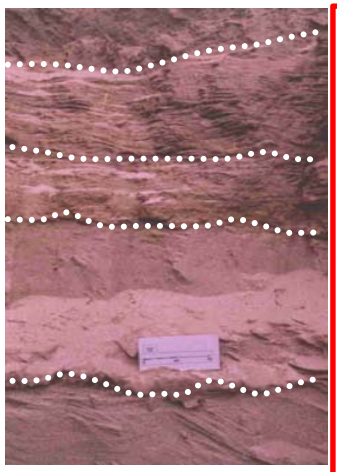

**Eric Steen Hansen, 2008**

# Lichenometry

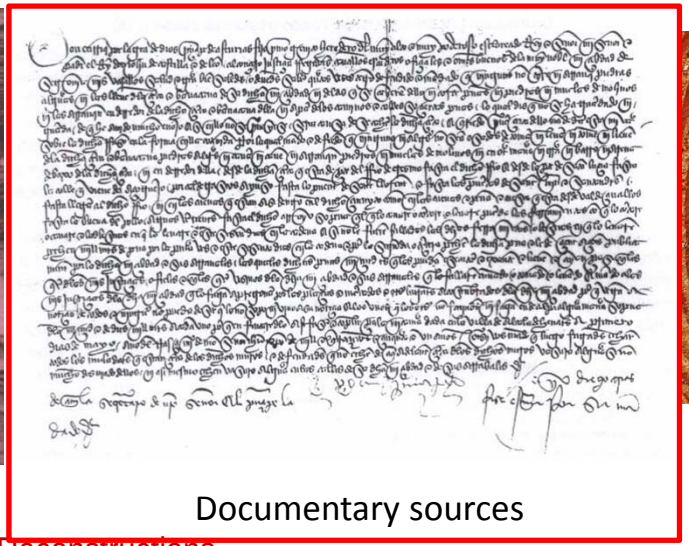



Lichens growing on a rockfall block at the Barretts landslide site (Bull, 2003)



Facies



Documentary sources

Tree rings and lichens

# HISTORICAL SOURCES

1. Types of historical documentary sources
2. Presumed problems
3. Methodology

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1. Types of historical documentary sources
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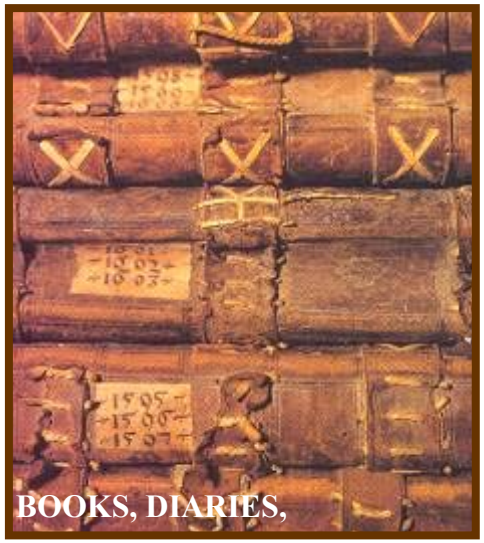
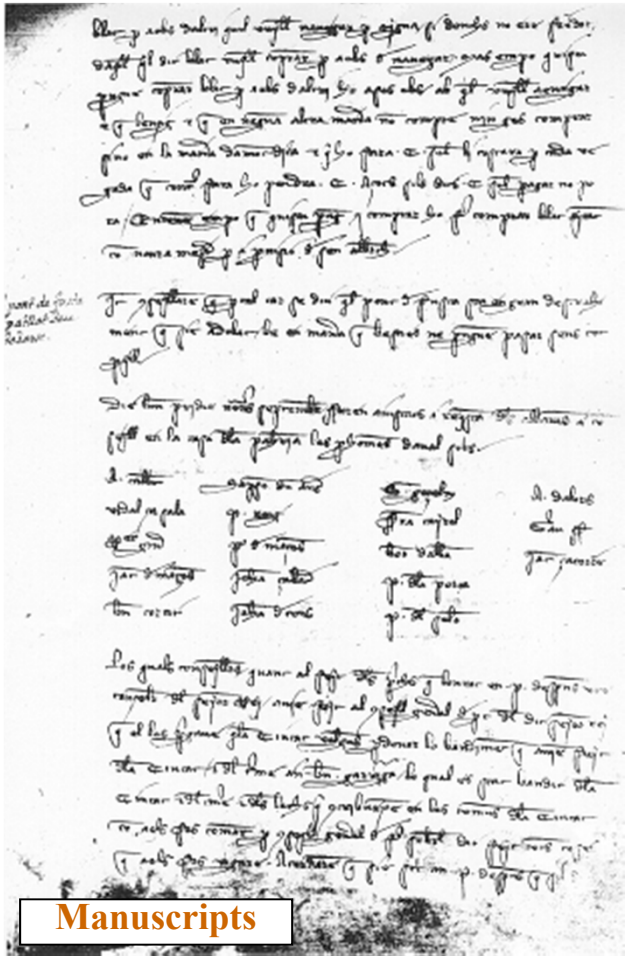
# Historical sources: types

Written documents

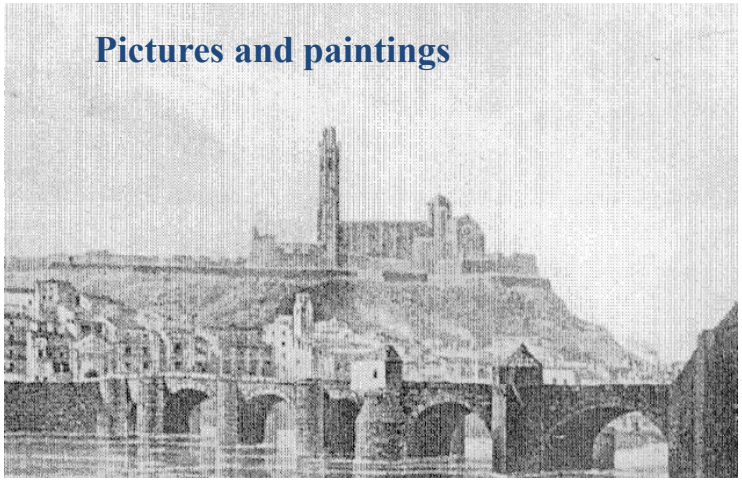

*Grape harvest dates*




# Historical sources: types

Printed documents and Iconography


Maps

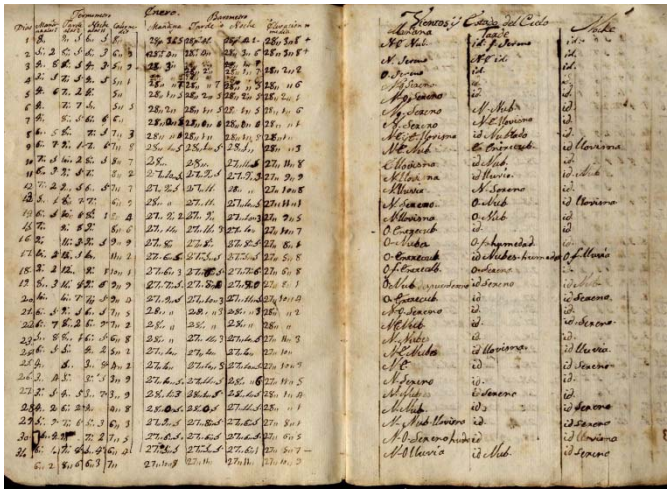


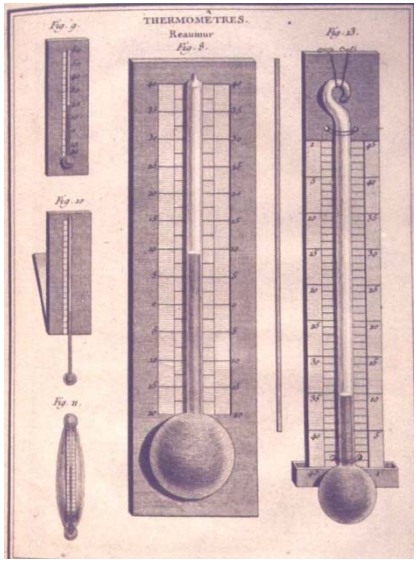
Pictures and paintings


*Epigraphical records. Stone-marks*

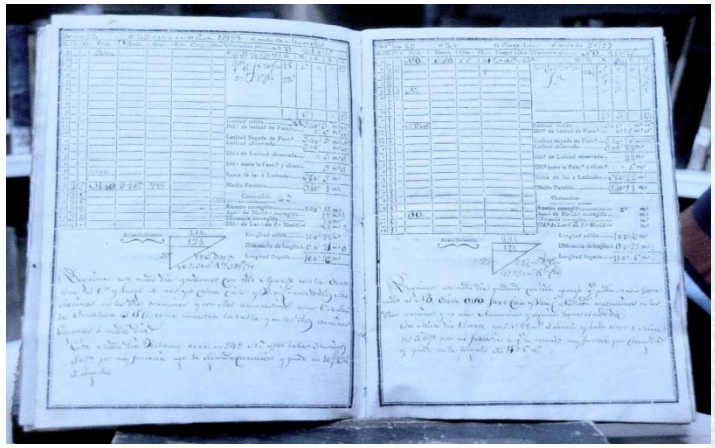
# Historical sources: types

meteorological measurements






Bitacora notebooks



# HISTORICAL SOURCES

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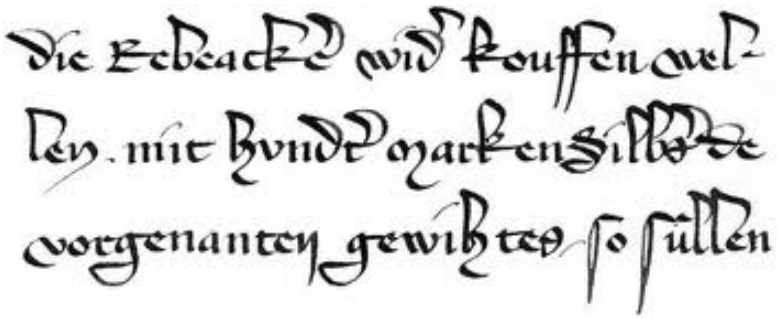
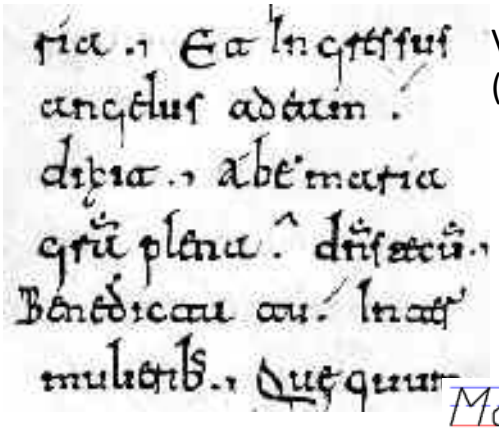
# Historical sources: Presumed problems

**Problems in handwritten texts interpretation**

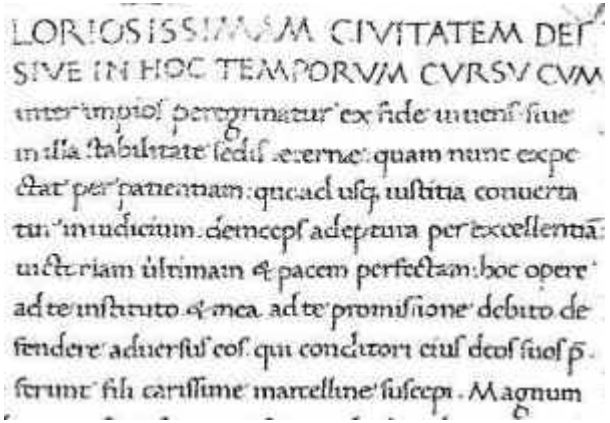
Uncertainties concerning the interpretation of historical texts



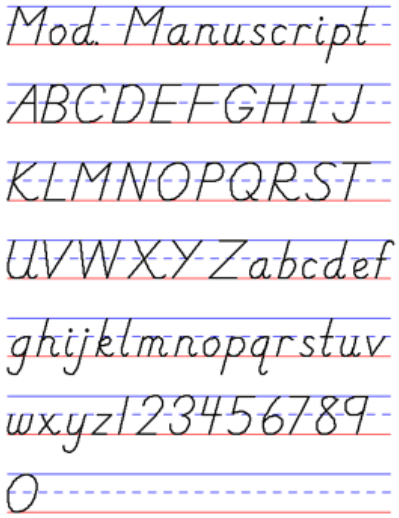
Gothic style (13th-14th centuries)



Visigothic style (9th-10th centuries)



Humanistic style (15th cent)




Modern style (16th cent-Current)

# Historical sources: Presumed problems

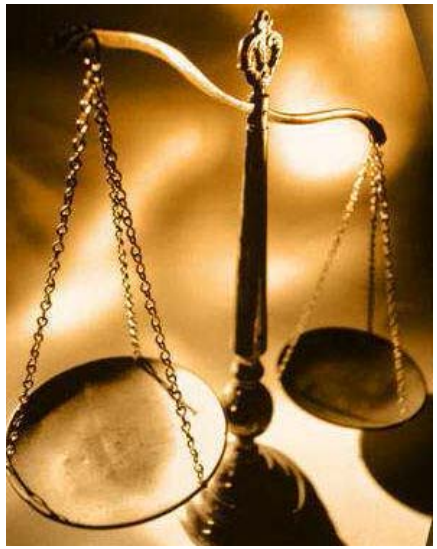
## *dating problems/dating inaccuracy*

It is possible to find unbalances in the respective calendars.

| Roman/Christian (after BC 46) | | Muslim after AD 622) | | French Revolution (AD 1793-1805) | |
|---|---|---|---|---|---|
| Ianuarius | 31 | Moharrem | 30 | Niv se | 30 |
| Februarius | 28-29 | afar | 29 | Pluvi se | 30 |
| Martius | 31 | Rebi el-awwel | 30 | Vent se | 30 |
| Aprilis | 30 | Rebi el-akhir | 29 | Germinal | 30 |
| Maius | 31 | Dschumada el- la | 30 | For al | 30 |
| Iunius | 30 | Dschumada el-akhira | 29 | Prairial | 30 |
| Iulius | 31 | Redschelo | 30 | Messidor | 30 |
| Augustus | 31 | Schaban | 29 | Thermidor | 30 |
| September | 30 | Ramadan | 30 | Fructidor | 30 |
| October | 31 | Schawwal | 29 | Vend miaire | 30 |
| November | 30 | Dhul-kade | 30 | Brumaire | 30 |
| December | 31 | Dhul-hiddsche | 29-30 | Frimaire | 30 |
| TOTAL | 365-366 | TOTAL | 354-355 | plus 5 days Sansculotides | |
| | | | | TOTAL | 365 |

# Historical sources: Presumed problems

**Measurement systems** before the unification of the metric system (mid 19th century) has anthropometric patterns. Most usual are feet and inches.

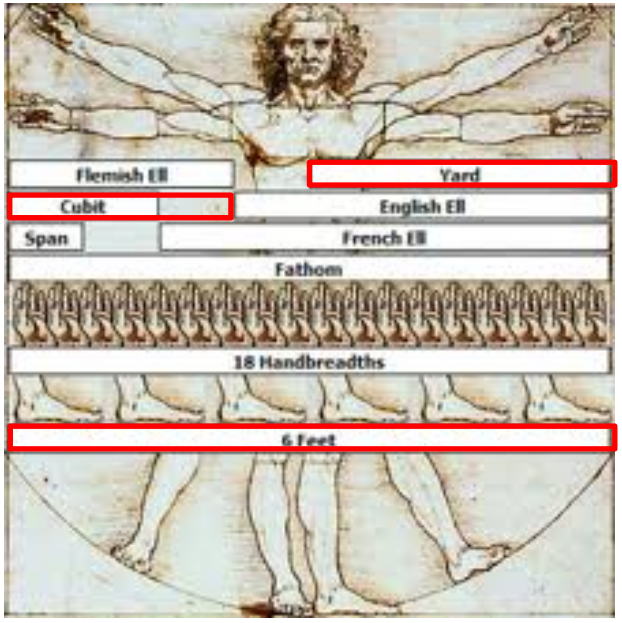


Spanish Kingdom:

| Burgos | Madrid | Teruel | Alicante |
|---|---|---|---|
| 1 Foot: 278,64 mm | 1 Foot: 281,00 mm | 1 Foot: 256,00 mm | 1 Foot: 304,00 mm |
| 1 Inch: 23,22 mm | 1 Inch: 23,41 mm | 1 Inch: 21,33 mm | 1 Inch: 25,33 mm |

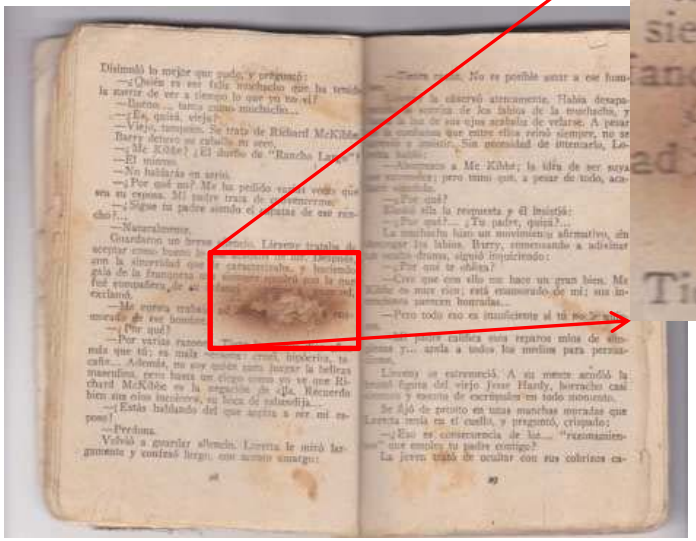
United Kingdom (British Foot):
1 Foot: 304,80 mm.
1 Inch: 25,40 mm.

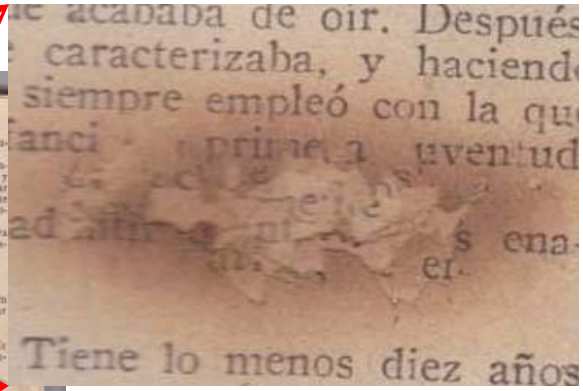
French Kingdom (Paris Foot):
1 Foot: 324,84 mm.
1 Inch: 27,07 mm.

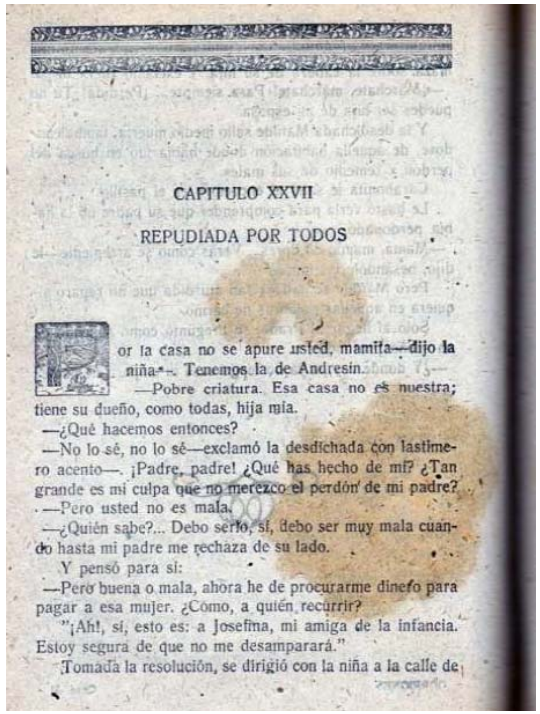


# Historical sources: Presumed problems

**Preservation and conservation**





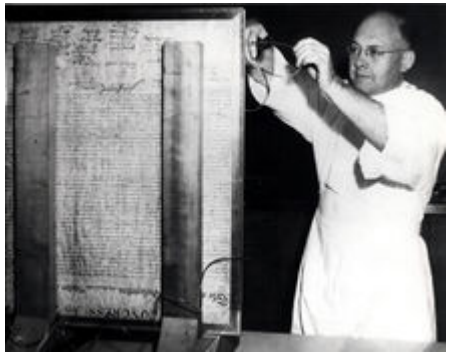

Landform Dating, Process Reconstructions

# Historical sources: Presumed problems

## Preservation and conservation

### Structural preservation techniques

### Technical preservation/conservation



### Digital preservation

# HISTORICAL SOURCES

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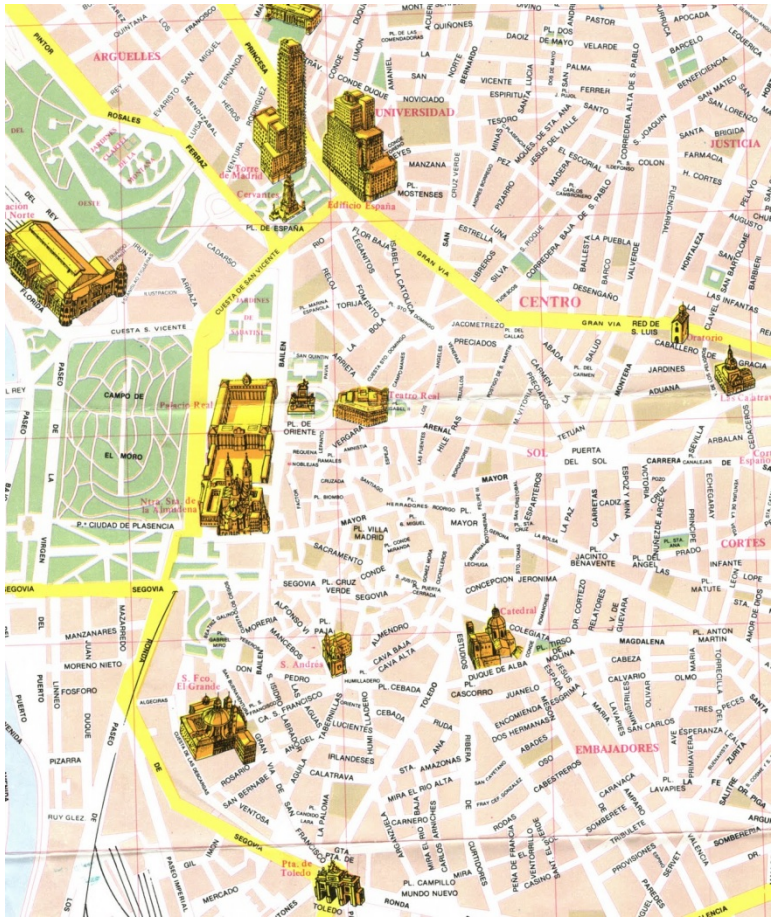
# Historical sources: methodology

Research procedures steps (based on Barriendos and Coeur, 2004):

**1 First approach to specific literature**

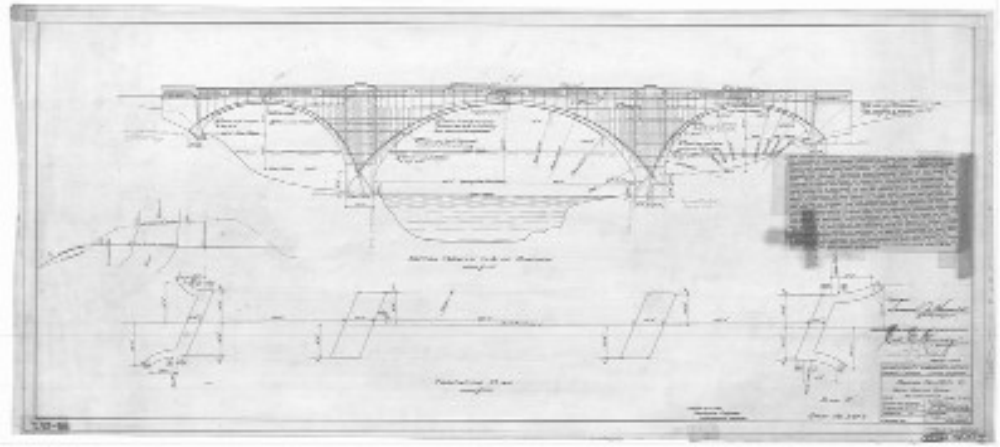
The first approach to bibliography by geographical location, temporal period to be studied and study matter

**2 Inventory (thematic list) of** all elements involved in the study. All materials and information obtained from bibliographical and documentary sources.



# Historical sources: methodology

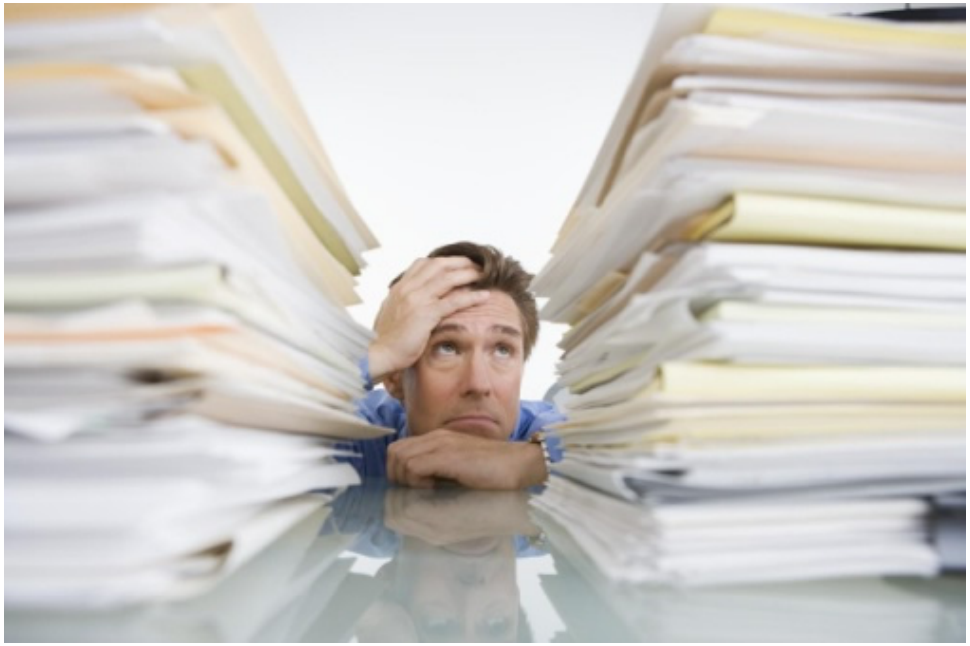
**3 List of the archives and documentary sources to be researched:** First reference list with archive inventories (if existing) or directly in the collections (work with the keeper or alone) is compiled.



# Historical sources: methodology

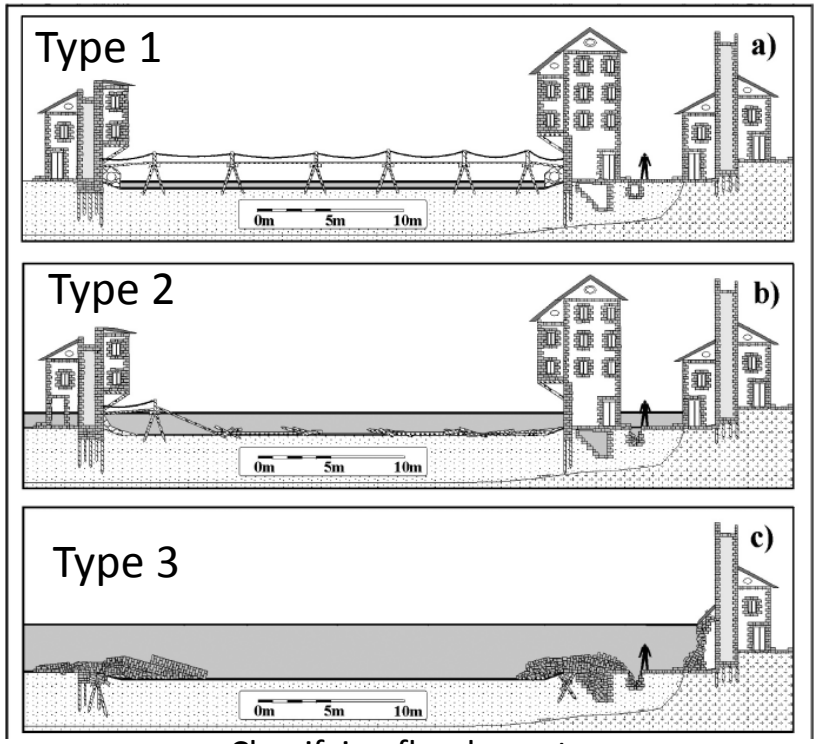
**4 Data collection:** must be, as much as possible, systematic and complete. All problems to manage the information found in documents must be resolved employing auxiliary technics.

**5 Data storage:** information collected can be organized and recorded in electronic format by means of different software applications.

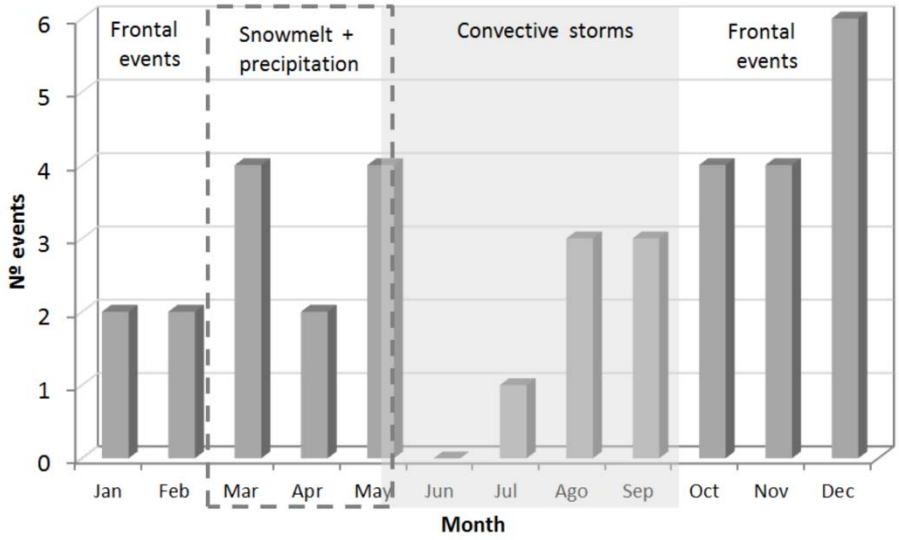


# Historical sources: methodology

**5 Data analysis:** Following the specific objectives of every research and workplan, data can be treated. Experience from historical sources show that it is not easy to generate data in similar format than modern instrumental sources.




Classifying flood events
(Barriendos and Coeur, 2004; Bullón, 2011)




Seasonality analysis
(Ruiz-Villanueva et al., 2013)

# Historical sources: methodology

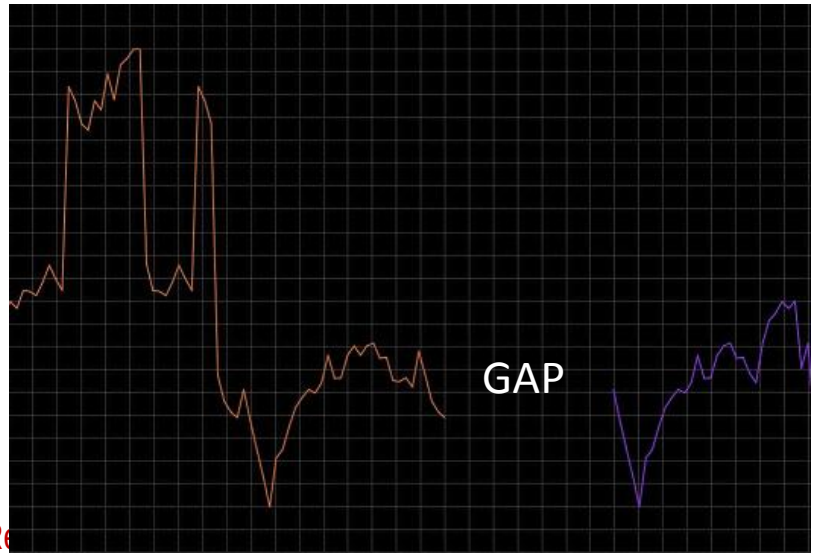
According to Le Roy Ladurie (1967), documentary sources for the study of climate effects should fulfil the following requests:

(i) the series must be annual (with the information organised in a temporal sequence which can be easily dated),

(ii) continuous (without gaps in the documentary records),

(iii) homogeneous (having a similar content throughout) and

(iv) quantifiable (containing information which can be processed statistically).



*THANK YOU FOR YOUR ATTENTION!*

*Virginia.ruiz@dendrolab.ch*