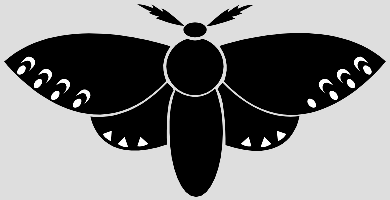
Dendroentomology: Forest insect ecology & recognizing insect signals in wood



- Signals of insect activity
- Related cross-dating issues
- A little bit about forest insect ecology
- Outbreak dynamics
- Dating outbreak events & building chronologies
- Analyzing chronologies & sampling considerations

Ann M. Lynch

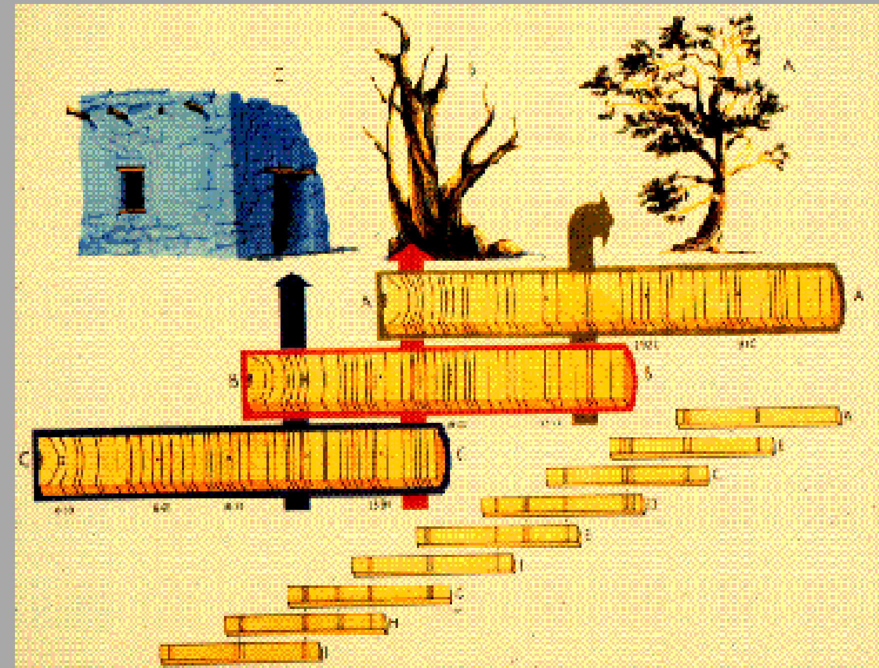
Research Entomologist & Assoc. Prof. Dendrochronology

Research Entomologist &	Assoc. Prof. Dendrochronology
USDA Forest Service	The University of Arizona
Rocky Mountain Research Station	Laboratory of Tree-Ring Research

Tucson AZ

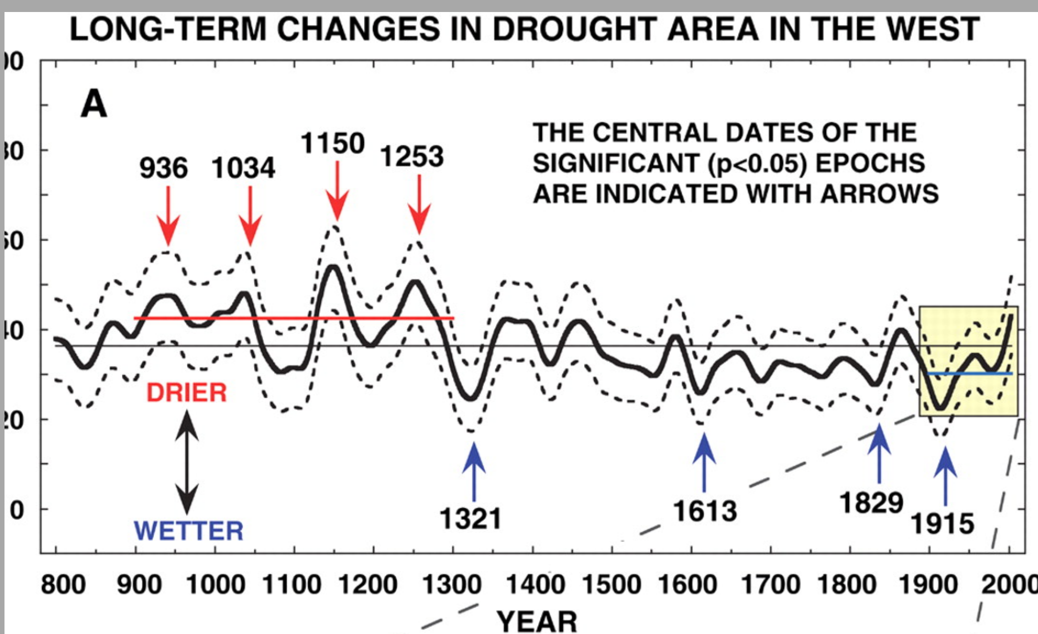
***alynch@LTRR.arizona.edu*, Room 317**

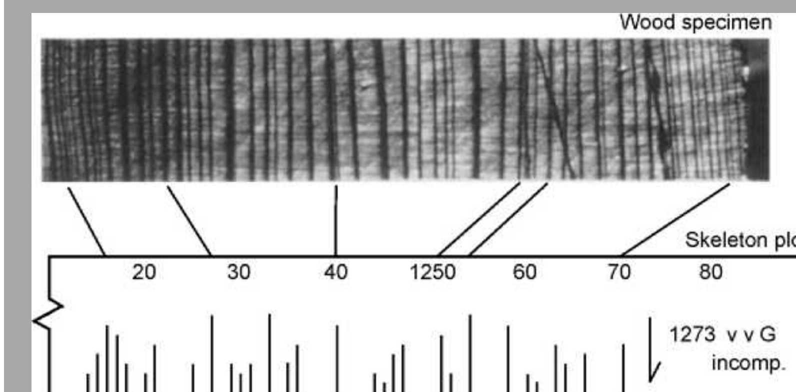
Why is this important?



Dating events
Dating structures
Reconstructing climate

Why should archeologists, climatologists, isotope jockeys care about insect outbreaks?





Insect herbivory frequently affects tree radial growth

- Recognize the departures for what they are
- Just because there are anomalies doesn’t mean that the material is not datable
- Insect populations often cycle with or respond to climate
- Forest character responds to insect outbreaks
  - Species abundance
  - Tree size
  - Stand density

Schulman 1953 *Climate Change*

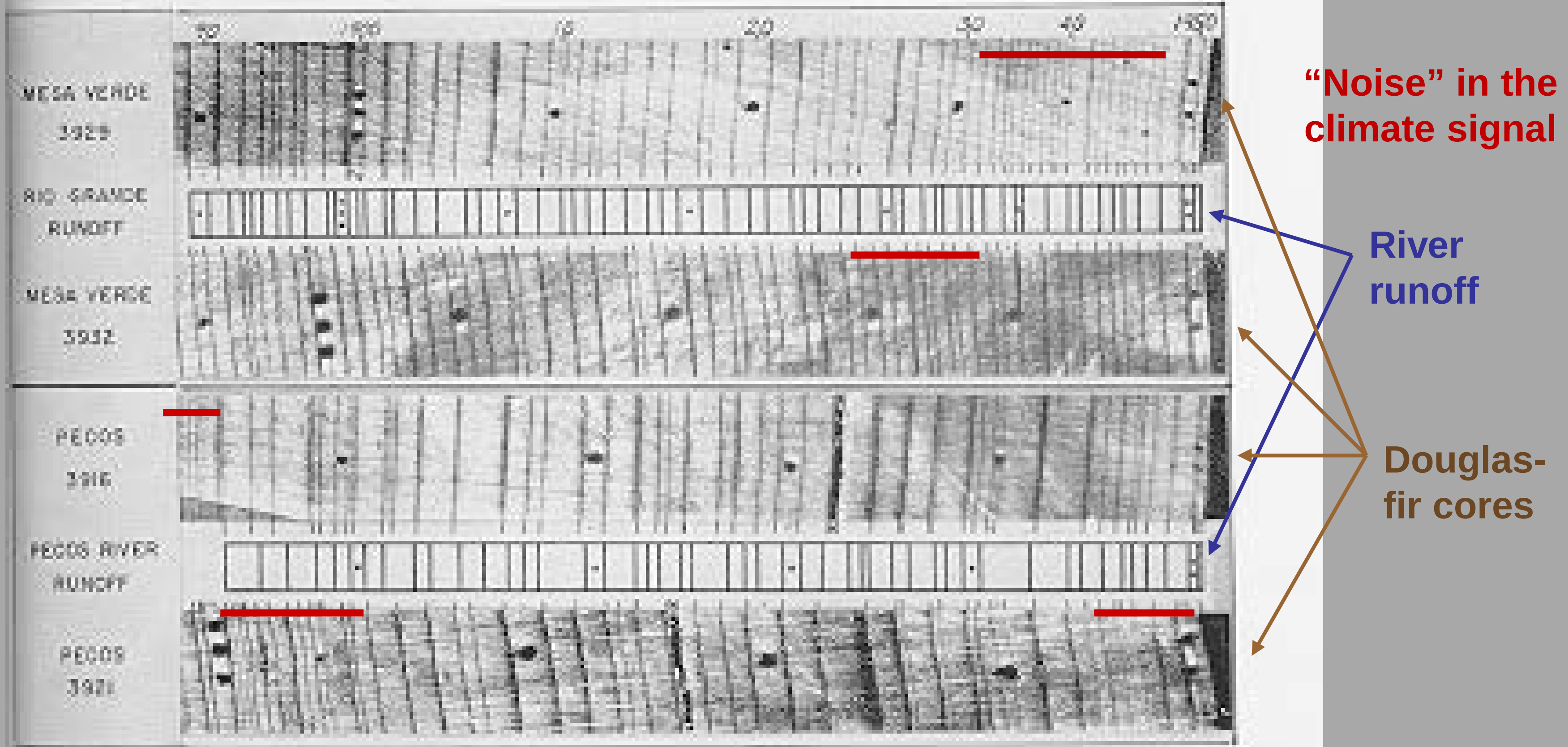
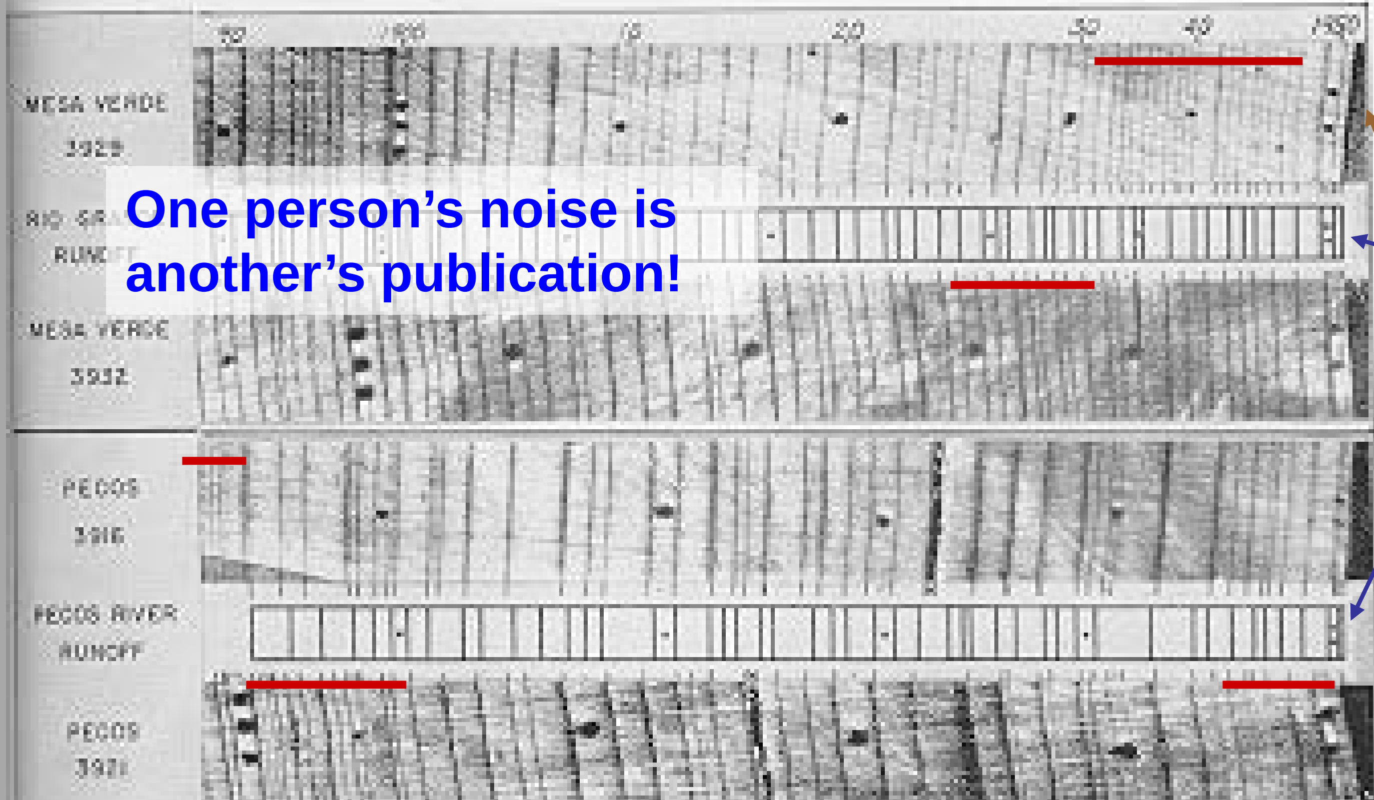


Fig. 1. *Upper panel*: Two ring sequences in Douglas fir (*Pseudotsuga taxifolia*) of high sensitivity from southwestern Colorado parallel the water-year runoff of the Rio Grande at Del Norte. *Lower panel*: Growth of the same species near Santa Fe, New Mexico, is compared with the runoff of the Pecos River at Pecos. The completed ring for 1951 is present under bark at the right. Ring boundaries marked along the edges of the photographs help to identify such structures as false rings for 1911 and 1913 and microscopic or locally absent rings at 1925 and 1934 in specimen 3916 (cf. the other photos at these dates). (From *Tree-Ring Bulletin*.)

Schulman 1953 *Climate Change*



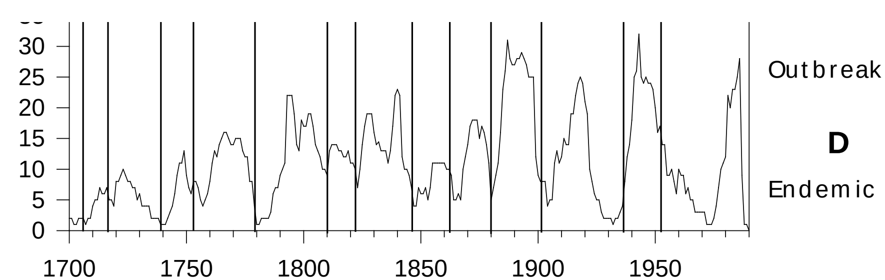
One person's noise is another's publication!

"Noise" in the climate signal

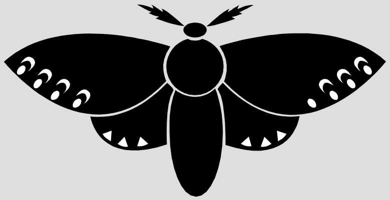
River runoff

Douglas-fir cores

Tree-ring reconstructions of western spruce budworm outbreaks (Swetnam & Lynch 1989, 1993; others).



Dendroentomology: Forest insect ecology & recognizing insect signals in wood



- Signals of insect activity
- Related cross-dating issues
- A little bit about forest insect ecology
- Outbreak dynamics
- Dating outbreak events & building chronologies
- Analyzing chronologies & sampling considerations

Ann M. Lynch

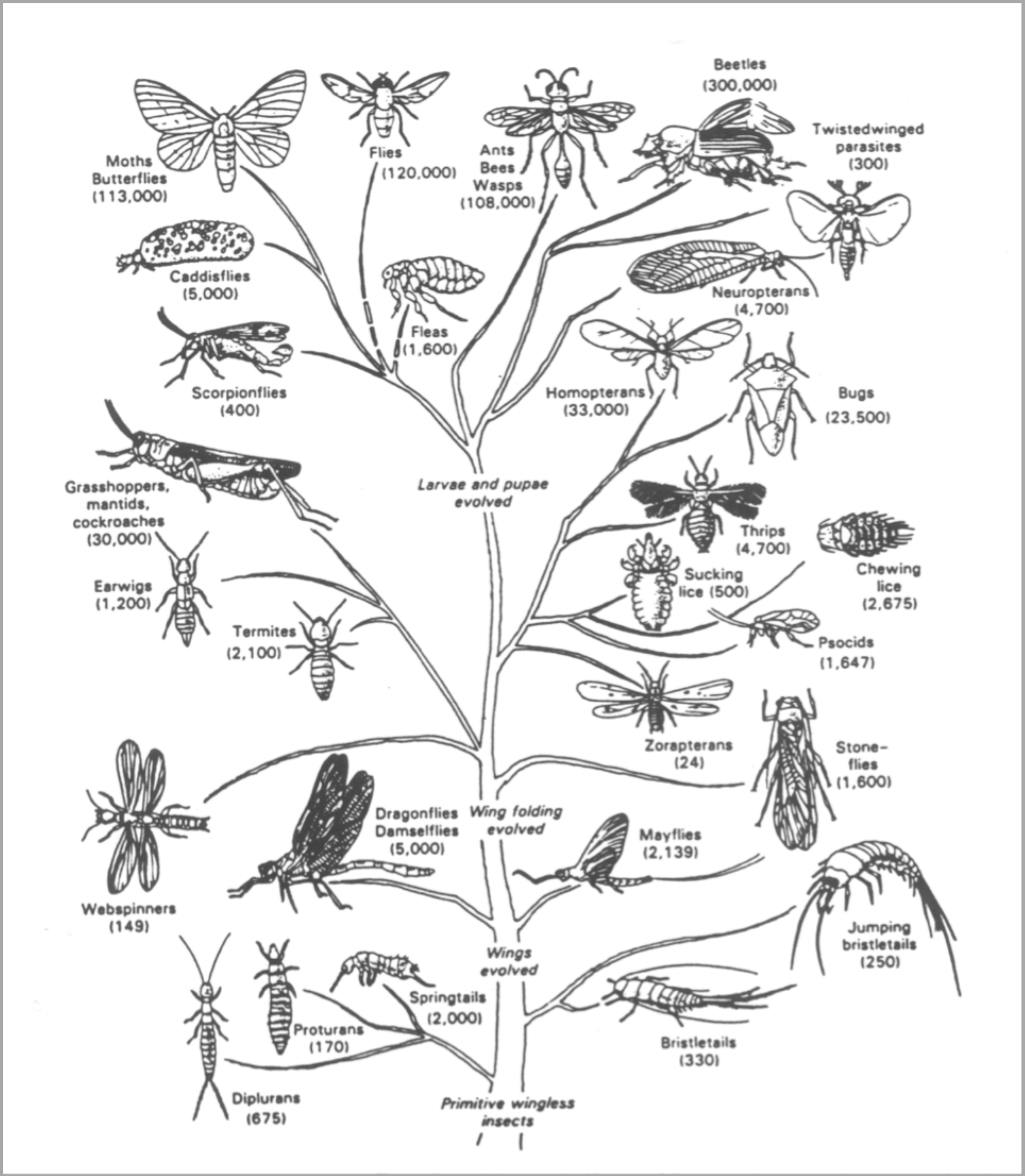
Research Entomologist & Assoc. Prof. Dendrochronology

USDA Forest Service — The University of Arizona

Rocky Mountain Research Station — Laboratory of Tree-Ring Research

Tucson AZ

alynch@LTRR.arizona.edu, Room 317



Blattodea
Coleoptera, particularly bark beetles
Collembolas
Dermaptera
Diplura
Diptera
Embiidina
Ephemeroptera
Grylloblattodea
Hemiptera, particularly sap suckers
Hymenoptera
Isoptera
Lepidoptera, includes most defoliators
Mantodea
Mantophasmatodea
Mecoptera
Microcoryphia
Neuroptera
Odonata
Orthoptera
Phasmatodea
Phthiraptera
Plecoptera
Protura
Psocoptera
Siphonaptera
Strepsiptera
Thysanoptera
Thysanura
Trichoptera
Zoraptera

From Wheeler et al. 2001. Cladistics 17: 113.

For management purposes, forest insects are categorized by:

- the part of the tree that they feed on (leaves, phloem, roots, sap, seeds, etc.)
- &/or by feeding mechanism

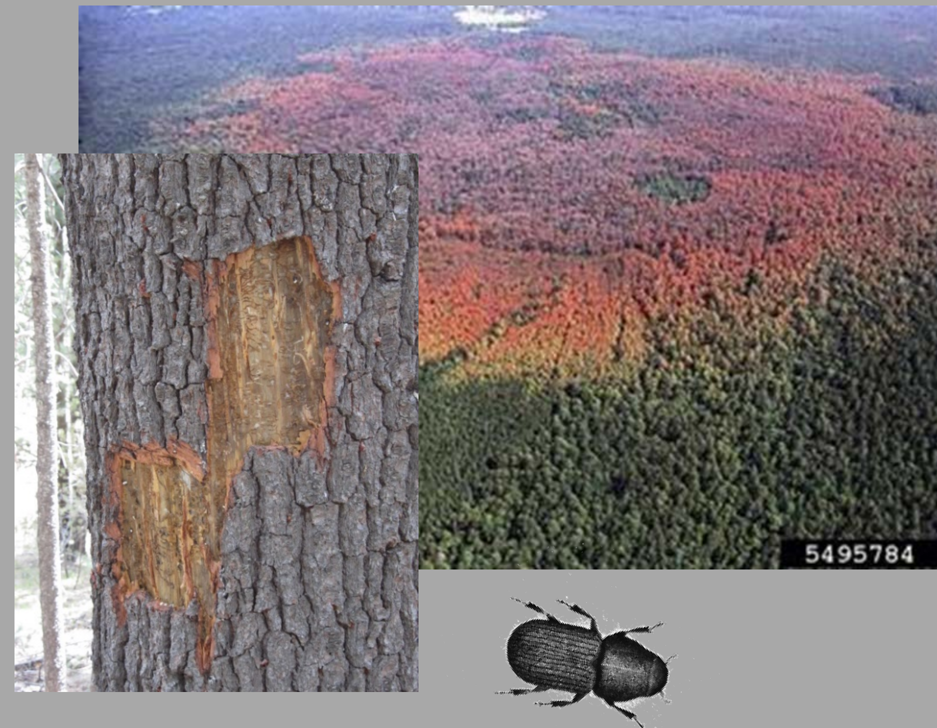
defoliators

sap-suckers

bark beetles

other stuff

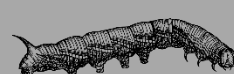
In dendrochronology, we generally distinguish between defoliators, mortality agents, & chronic pests



Bark beetles are obligate mortality agents

- consume phloem tissue
- disrupt water flow
- kill trees (usually, brood cannot develop unless tree dies)
- sometimes associated with staining fungi which contribute to tree death

Defoliators

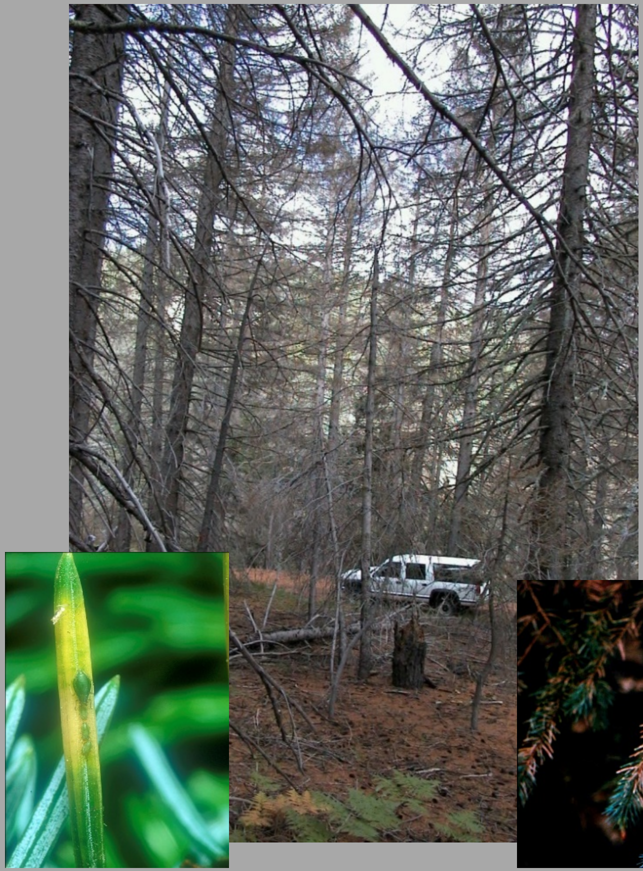


- directly consume foliage
- photosynthetic & transpiration capacity reduced
- growth effects
- sometimes causes mortality

<u>SAP-SUCKING</u> **insects feed on phloem fluid or dissolved parenchyma**

Foliage may die and trees defoliate, but mechanisms are very different from that of a leaf-chewing insect

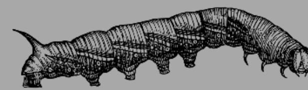
pine bark adelgid
Pineus strobi
(Hemiptera: Aphididae)



Spruce aphid
Elatobium abietinum
(Hemiptera: Aphididae)

Pinyon needle scale, *Matsucoccus acalyptus*
(Hemiptera: Margarodidae)

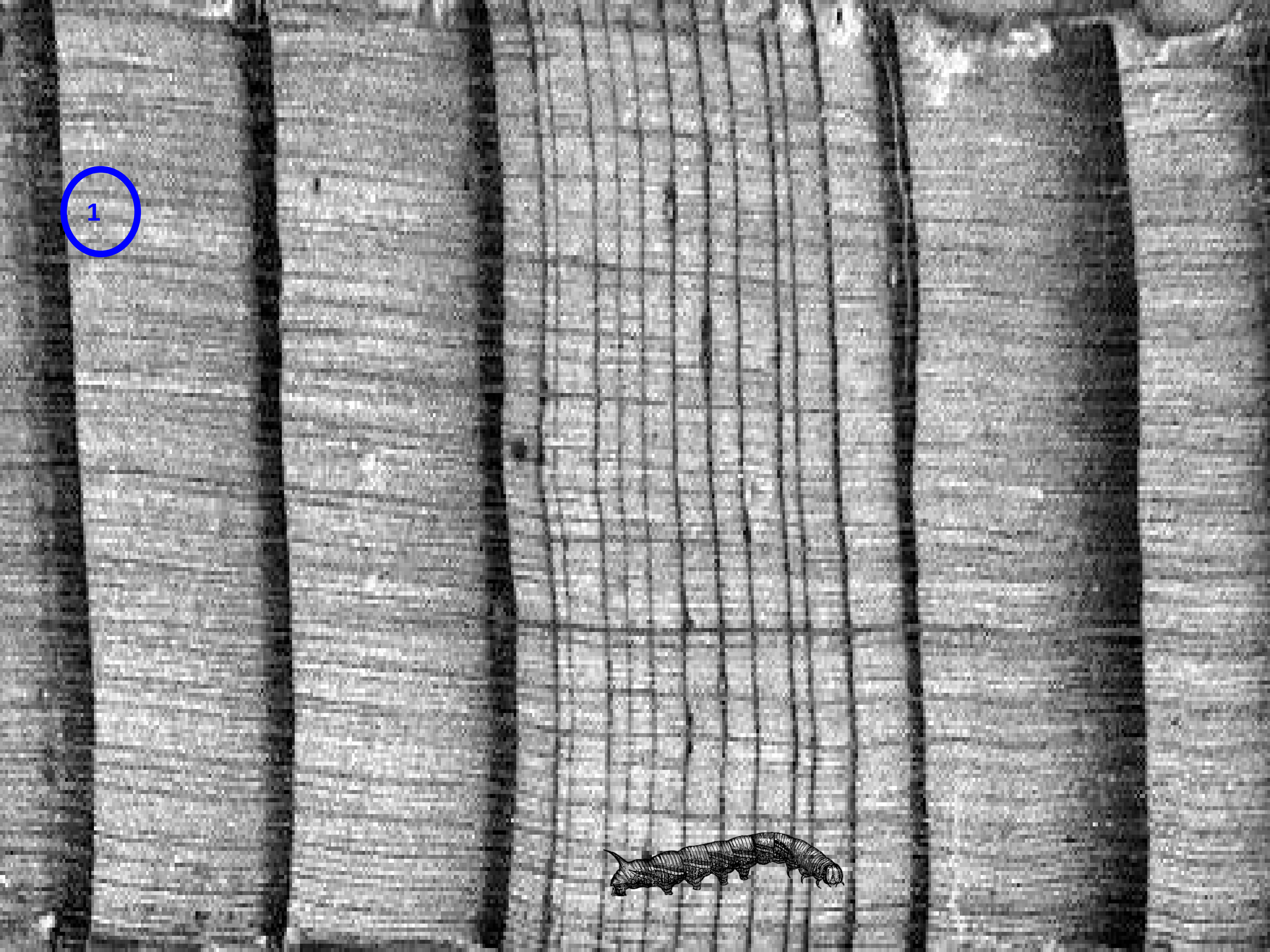
<u>Defoliators</u>:

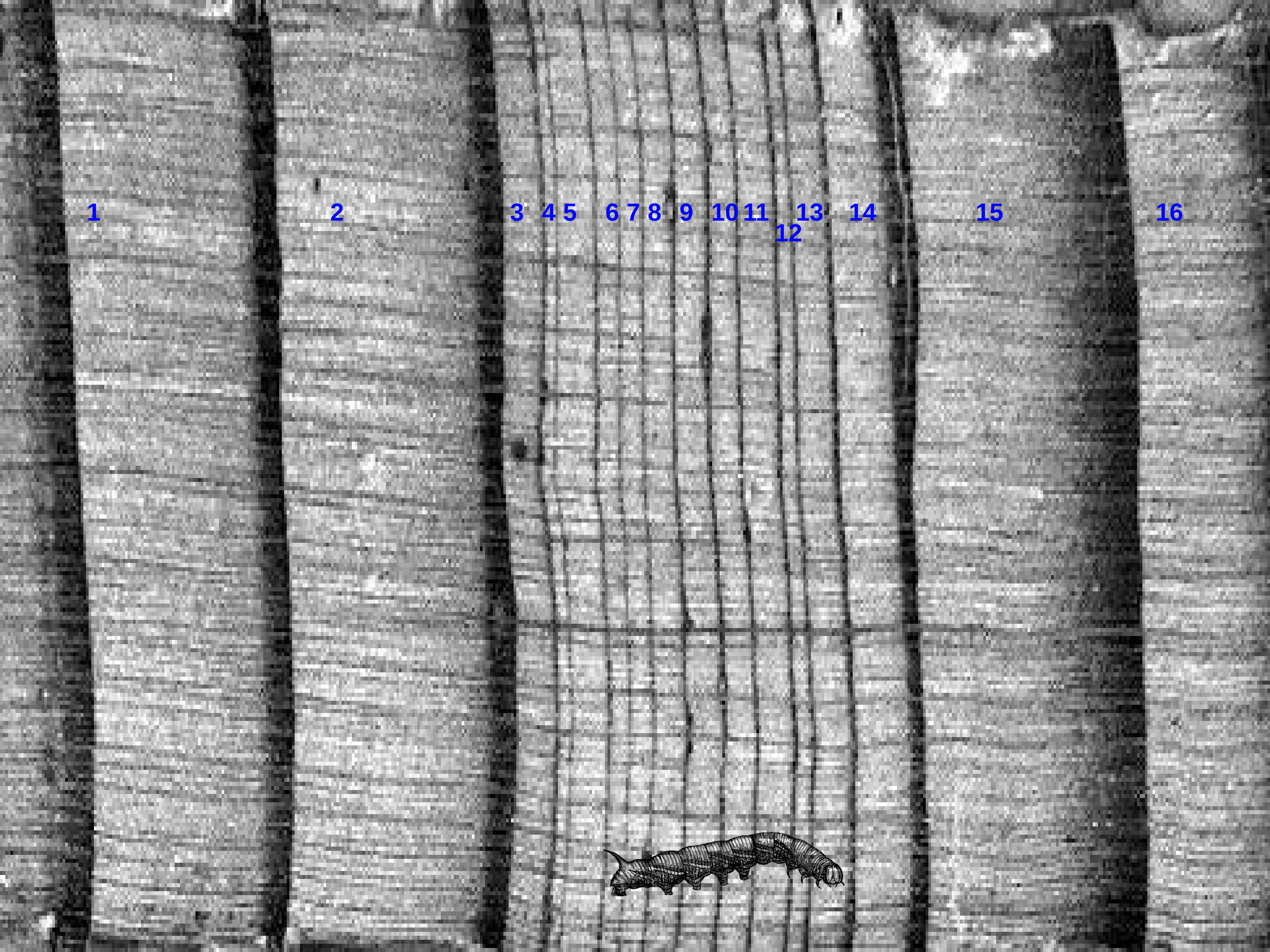


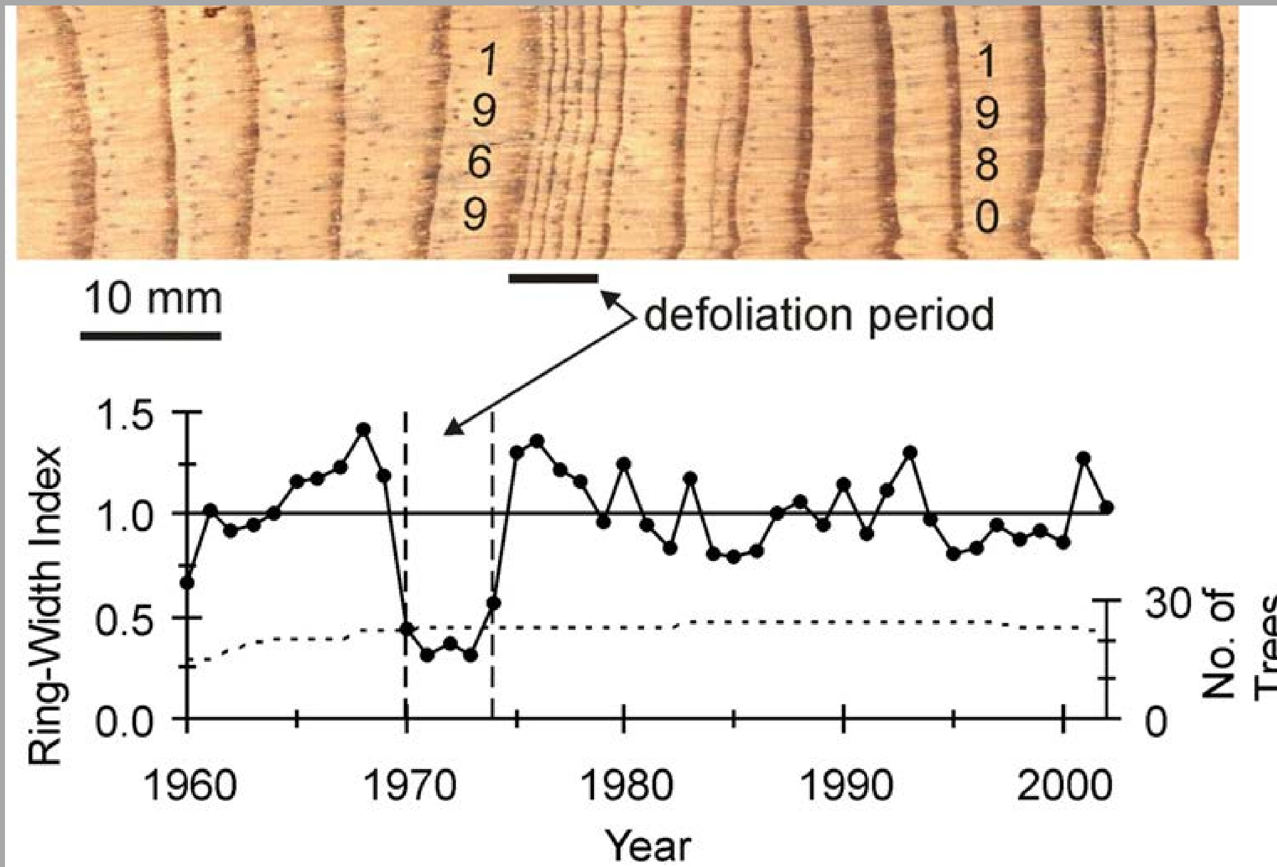
Consume foliage

Majority are moths & butterflies

Mortality levels vary


1

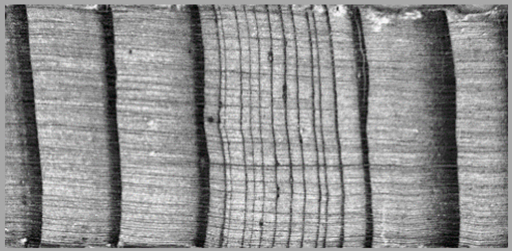

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16



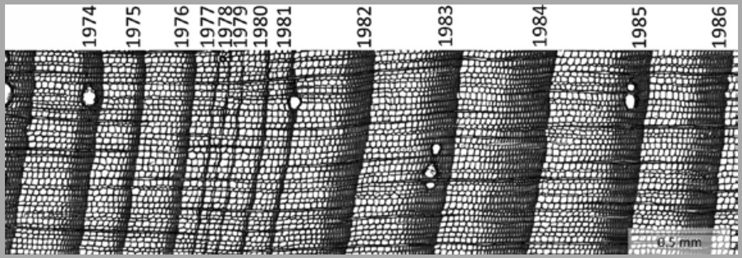
Increment core & ring-width series from Michoacan pine defoliated by sawflies in southern Mexico (P. Sheppard)

Photo: Ponderosa pine defoliated *Neodiprion fulviceps*, Bull Basin, Kaibab N.F., Arizona (A. Lynch)

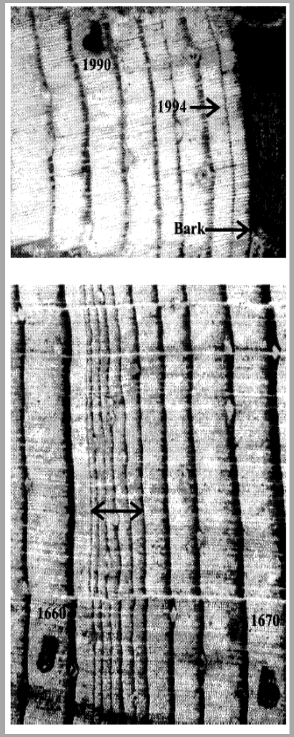
Defoliator effects on tree-rings



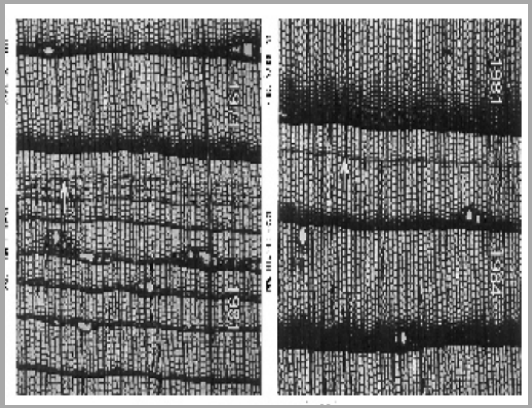
Reduced RW. **Western spruce budworm in white fir, Swetnam *et al.,* various.**



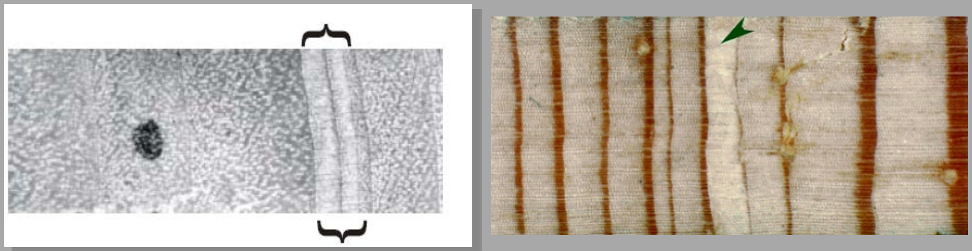
Changes in lumen area & cell-wall thickness.
WSBW, Axelson et al. 2014



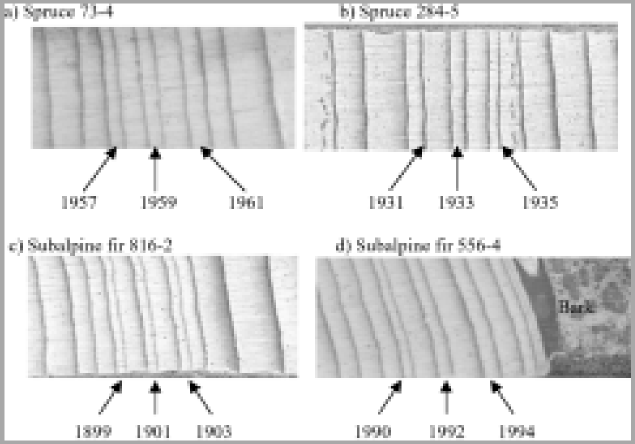
Thin latewood (both) and **reduced RW** (bottom).
Pandora moth in ponderosa pine, Speer *et al*. 2001.



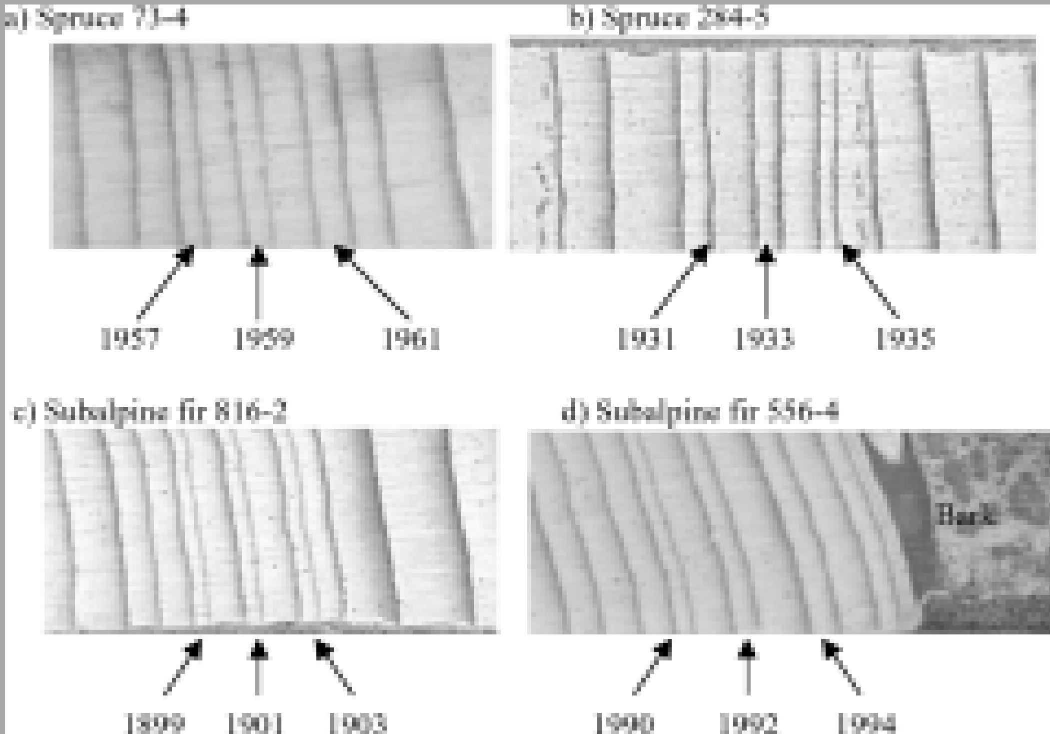
Reduced RW & density of LW.
Larch budmoth, Weber 1997



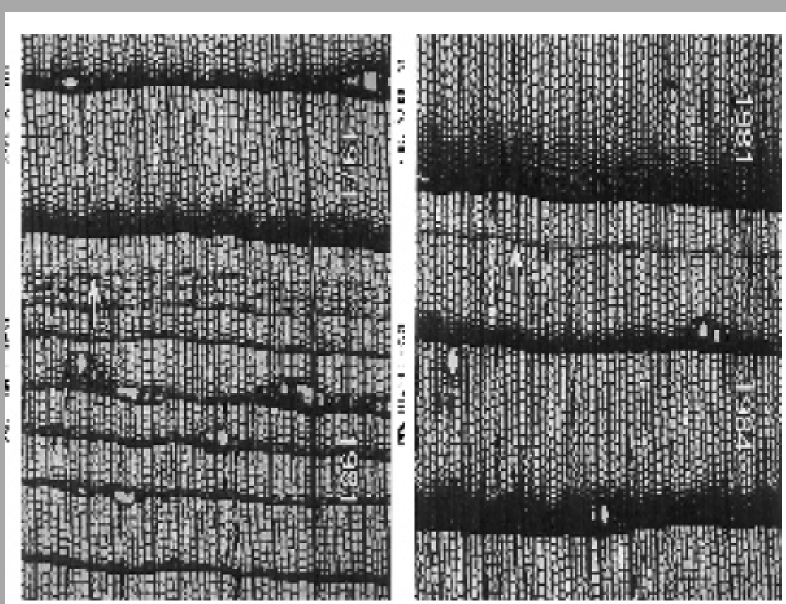
Light or white rings. **Left: Western tent caterpillar in aspen, Margolis *et al*., unpbl. Right: Pandora moth in ponderosa pine, , García-González *et al*., unpbl.**



Distinct patterns: **Small rings formed every-other year by two-year cycle budworm (*Choristoneura biennis*), Zhang & Alfaro 2002.**



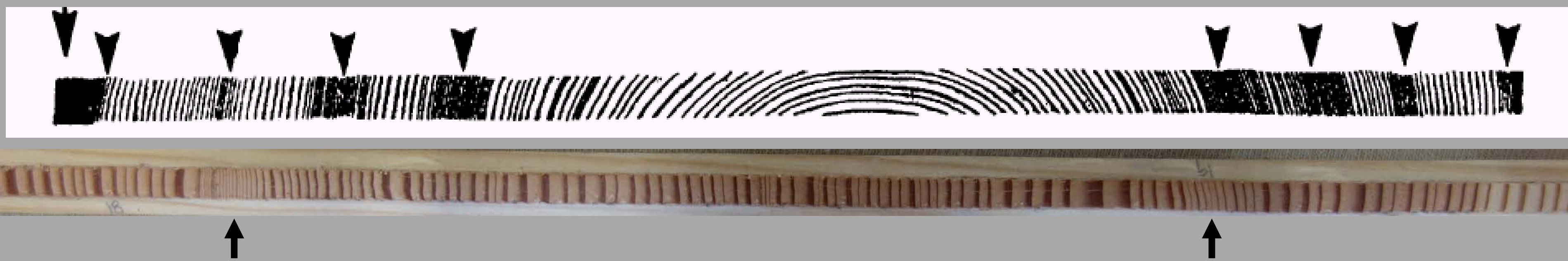
Two-year cycle budworm (*Choristoneura biennis*)



Larch budmoth

Zeiraphera griseana

Defoliator effects on tree-rings



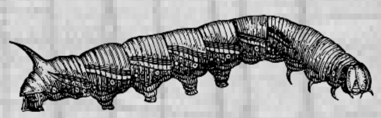
Repeated outbreaks may or may not be periodic or quasi-periodic. WSBW, Swetnam & Lynch 1993.

Common signals associated with defoliators:

- **Consecutive narrow rings**
- **Thin latewood**
- **Changes in density, especially in the latewood**
- **White rings**
- **Missing rings**

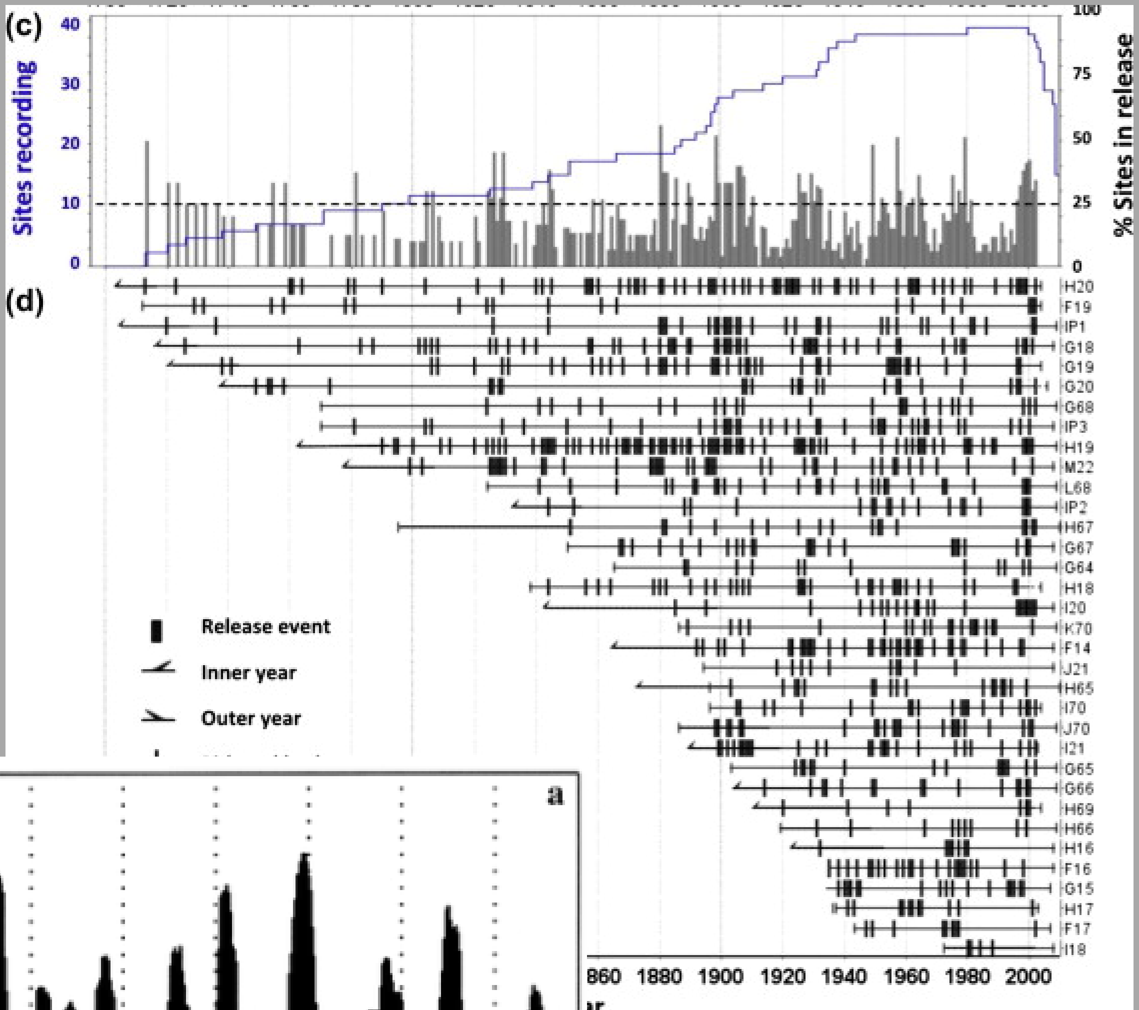
Known to occur, but not well studied:

- **Changes in wood chemistry**
- **Changes in cell structures**
  - **Lumen area**
  - **Cell wall thickness**

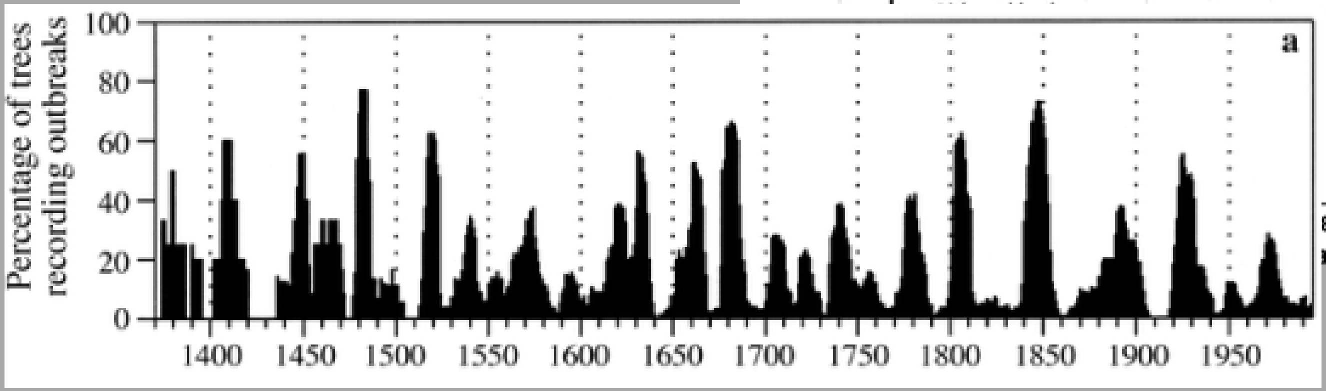


Reconstructing forest insect outbreak chronologies

- Frequency
- Duration
- Interval length
- Periodicity
- Assoc. w/ climate
- etc.



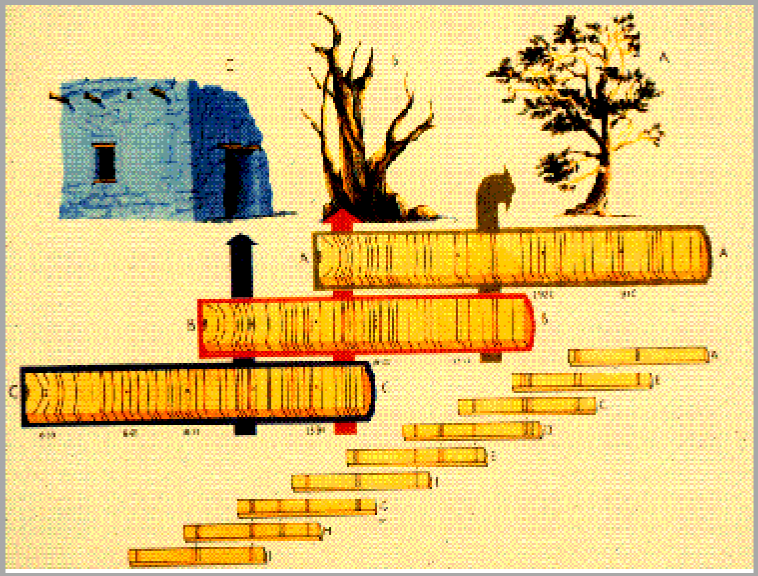
Spruce beetle outbreak chronology from Pinaleños (O'Connor et al. 2015. FE&M 336: 148)

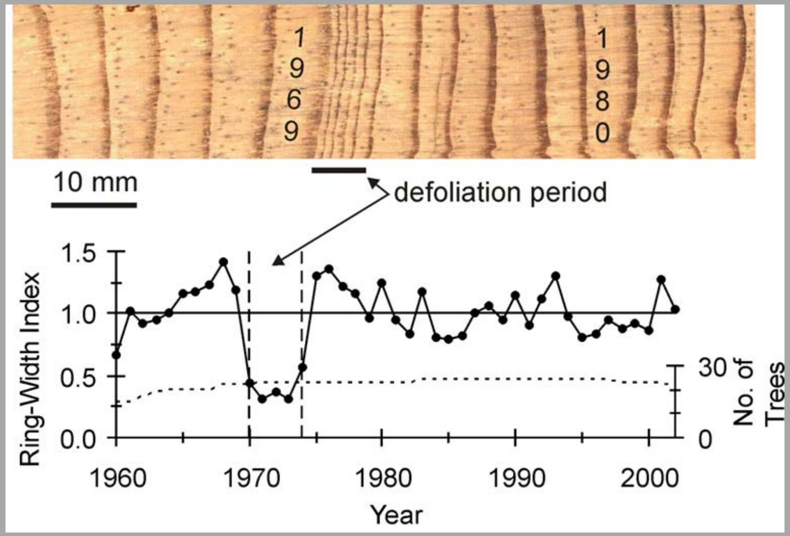


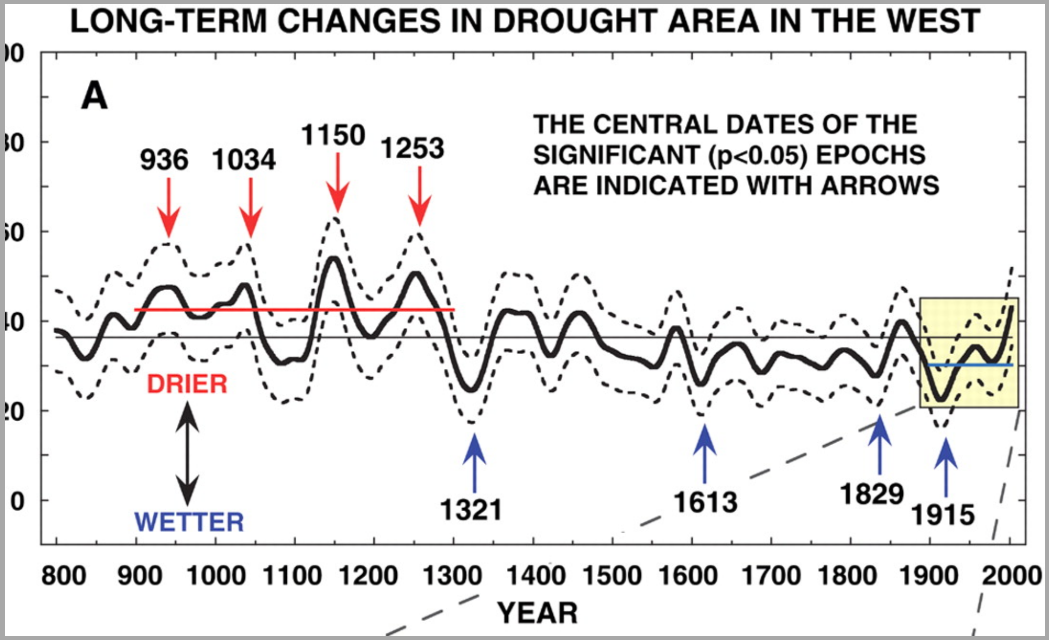
Pandora moth outbreak chronology from central Oregon (Speer et al. 2001. Ecology 82:679)

You other folks

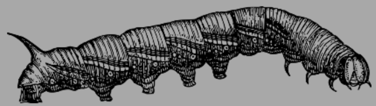
- Recognize anomalies for what they are
- Wood is often still datable
- Missing rings occur more frequently during defoliation
- May or may not be usable for your objective





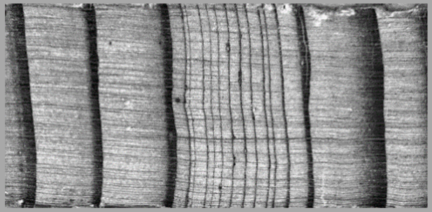


Cross-dating issues



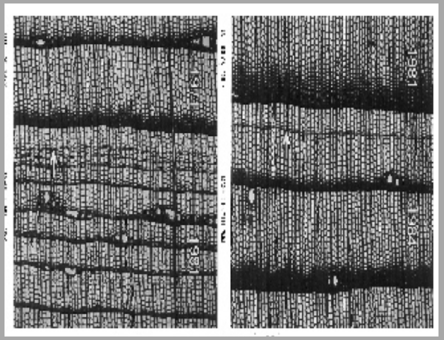
Recognize what you see for what it is

- **Tree species**
- **Know the major pests & host-specificity (*Google Scholar* is your friend but no substitute for an expert)**
- **Do not reject just because of anomaly**
- **Helps to have a provenance!**



Cross-date on both sides of the signal

- **Rings may be missing!**
- **Which years are missing can't always be determined**



Many insects have somewhat periodic cycles, which may be driven by climate, weather, & fire

Affects sensitivity, coefficients, & correlations

And yes, <u>sometimes</u> outbreaks are so frequent & severe that the material cannot be dated

Phloem tissue feeders:

Consume phloem tissue

Overwhelming majority are bark beetles

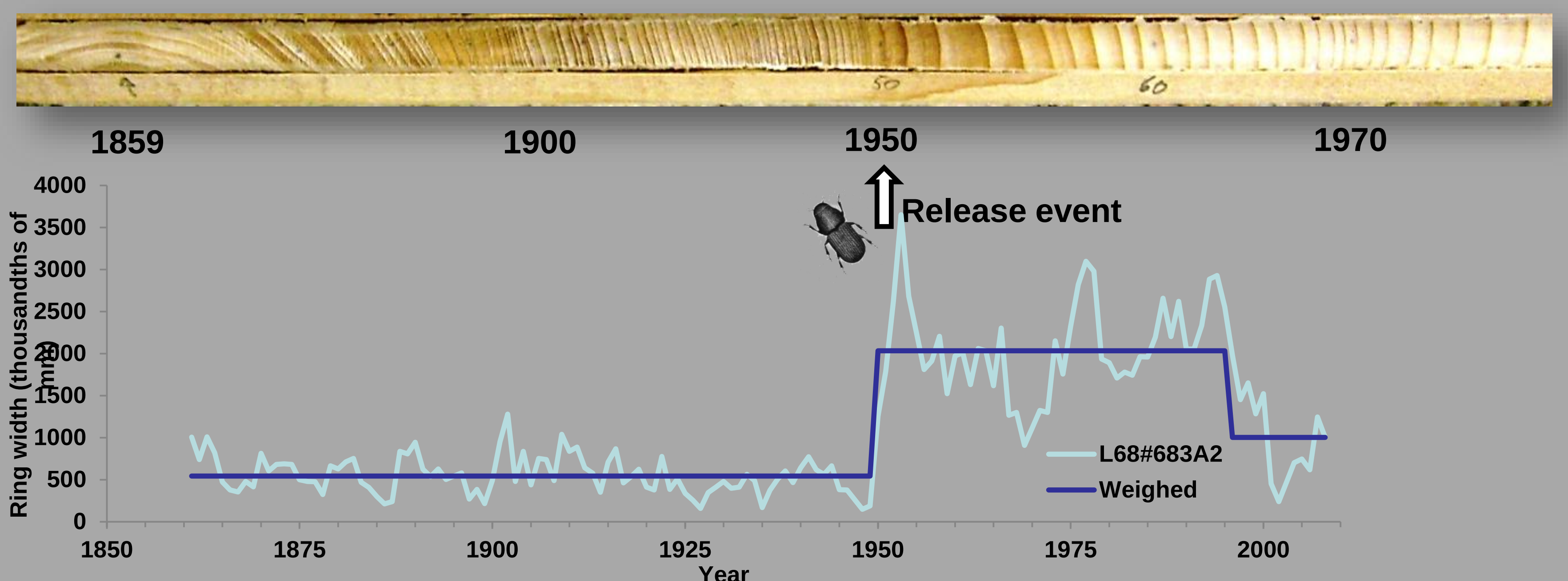
Require "mass attack" by <u>many</u> beetles

Obligate mortality agents; in a few instances only a portion of the tree dies

Stain fungi

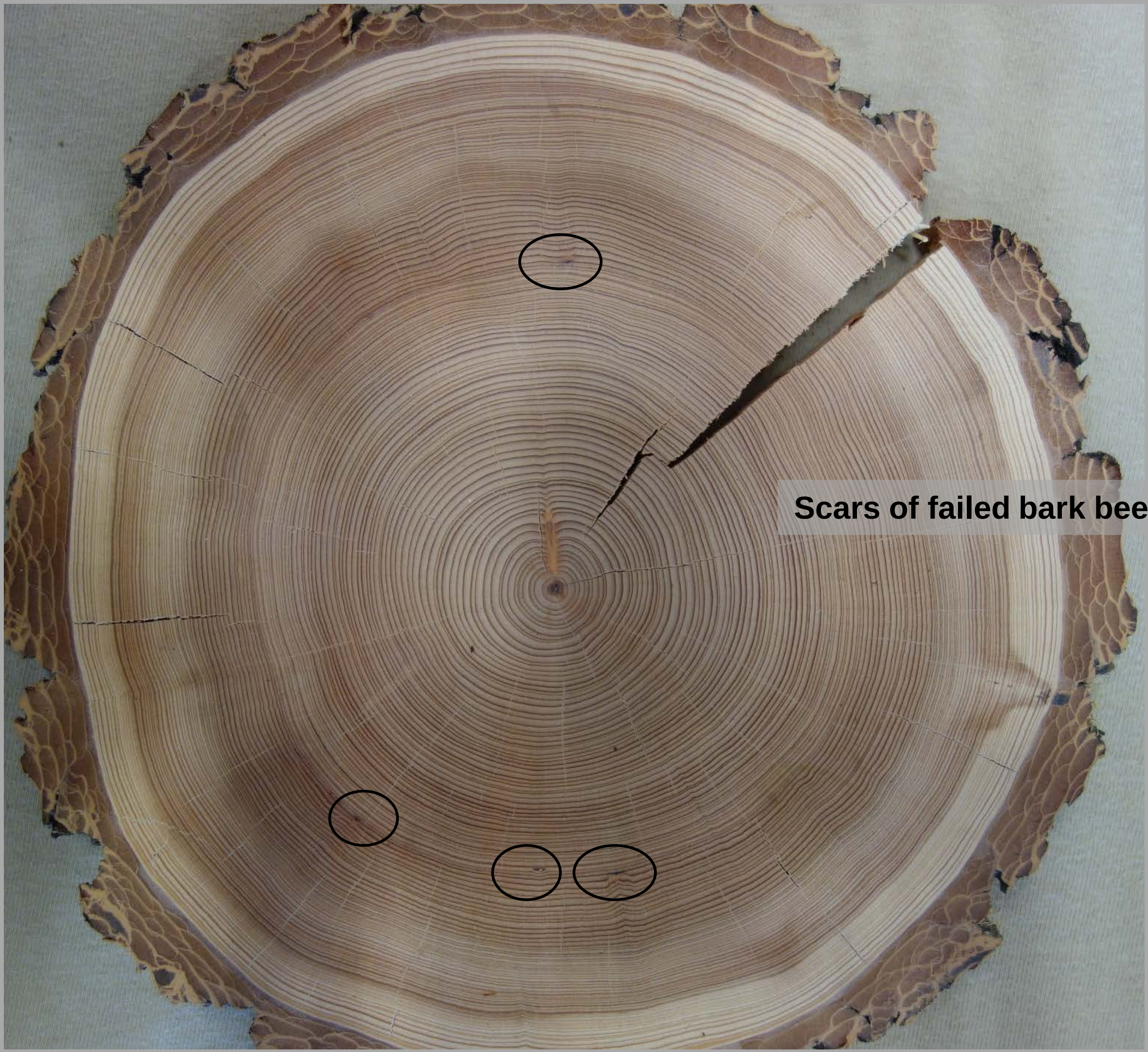
Often associated with drought, but not every species

Tree ring signatures of mortality agents, esp. bark beetles

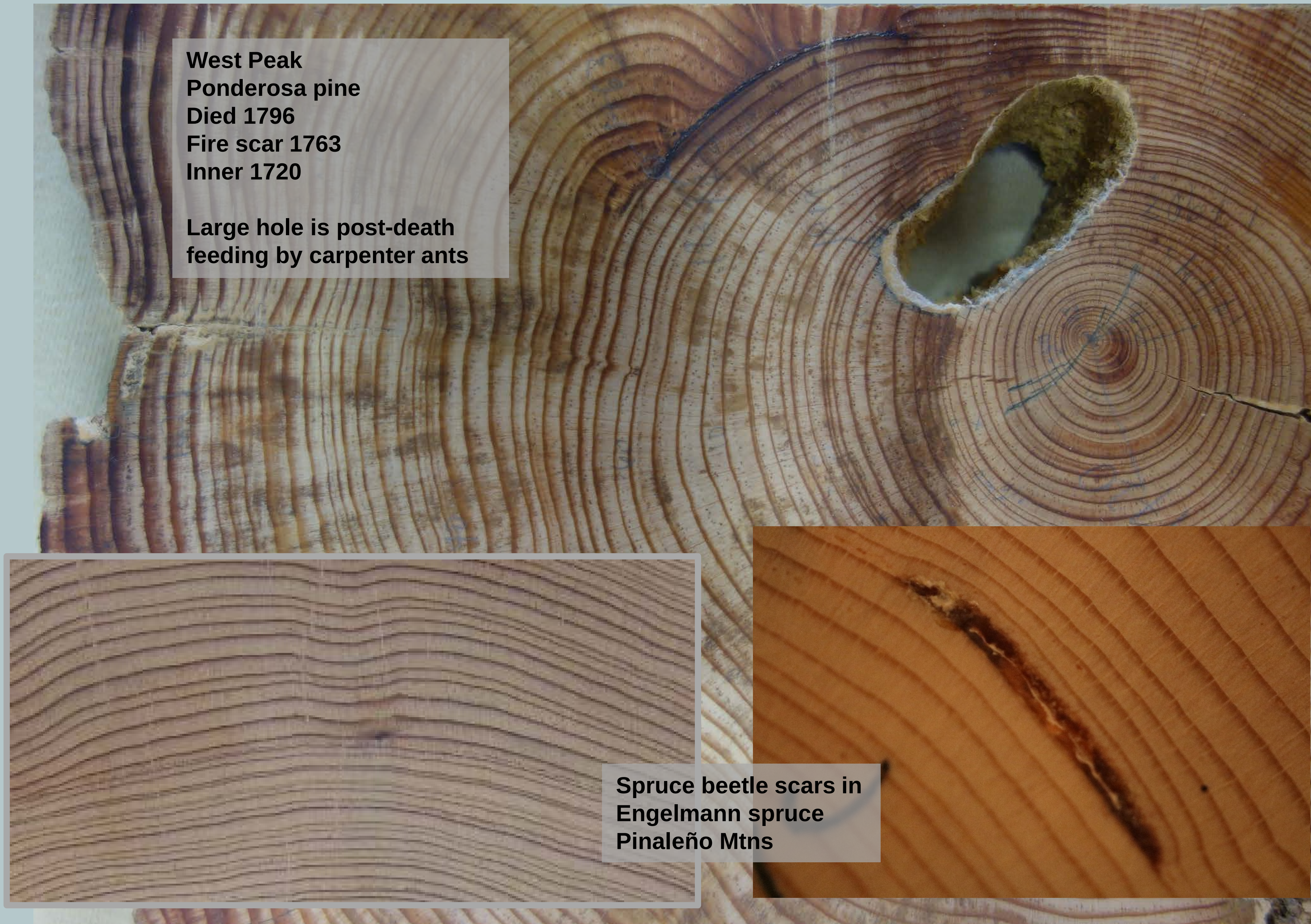


Bark beetle effects on tree-rings

- Growth surges (may lag mortality event)
  - Tightly clustered from extreme abrupt disturbance
  - Clustered but staggered from expansive events
- Death dates of snags & residual material
- Physical evidence: gallery scars, micro-scars of failed attacks
- Diameter & species distributions of dead trees vs survivors
- Recruitment pulses
  - long variable lags possible in many systems
  - event → seed production → establishment conditions
  - less lag for seed-banking systems
  - confounding causal circumstances (fire exclusion, precipitation, climate change)



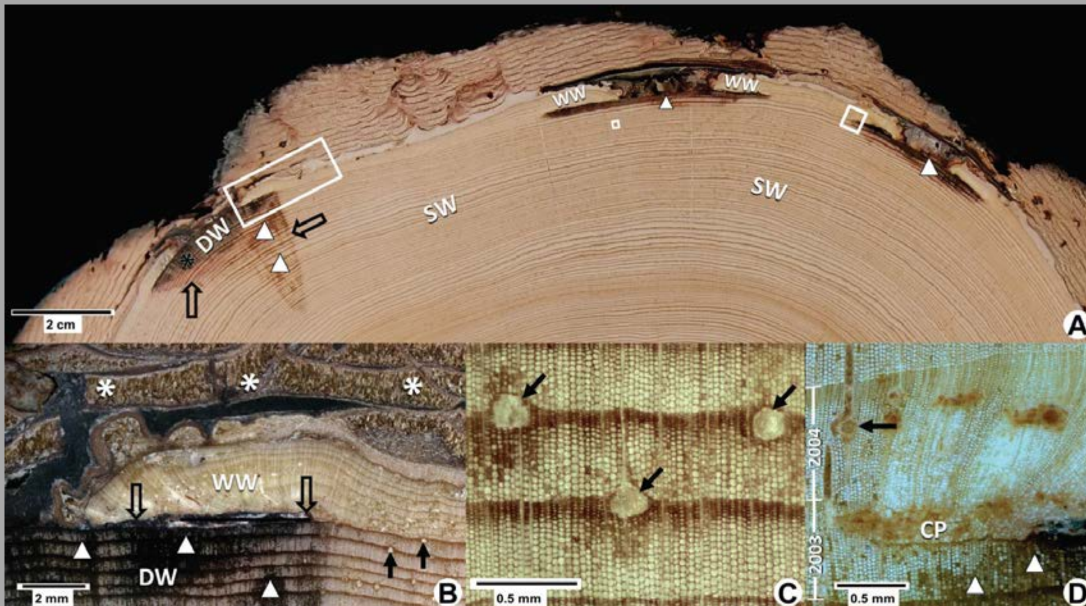
Scars of failed bark beetle attack, ~1950

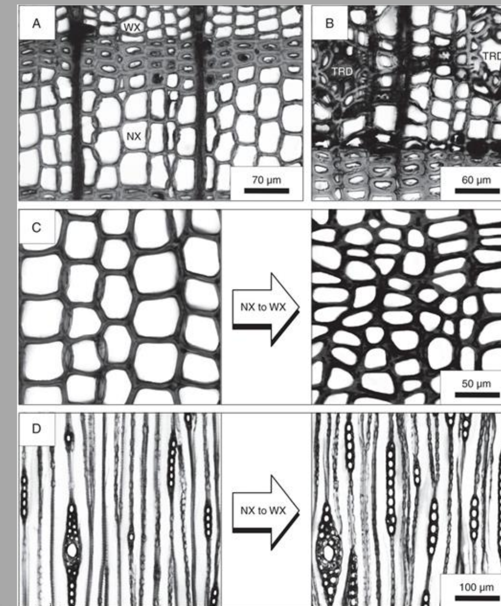

West Peak
Ponderosa pine
Died 1796
Fire scar 1763
Inner 1720
Large hole is post-death feeding by carpenter ants
Spruce beetle scars in Engelmann spruce Pinaleño Mtns

Macroanatomy of a fire scar

Smith et al. 2016

Arbellay et al. 2014





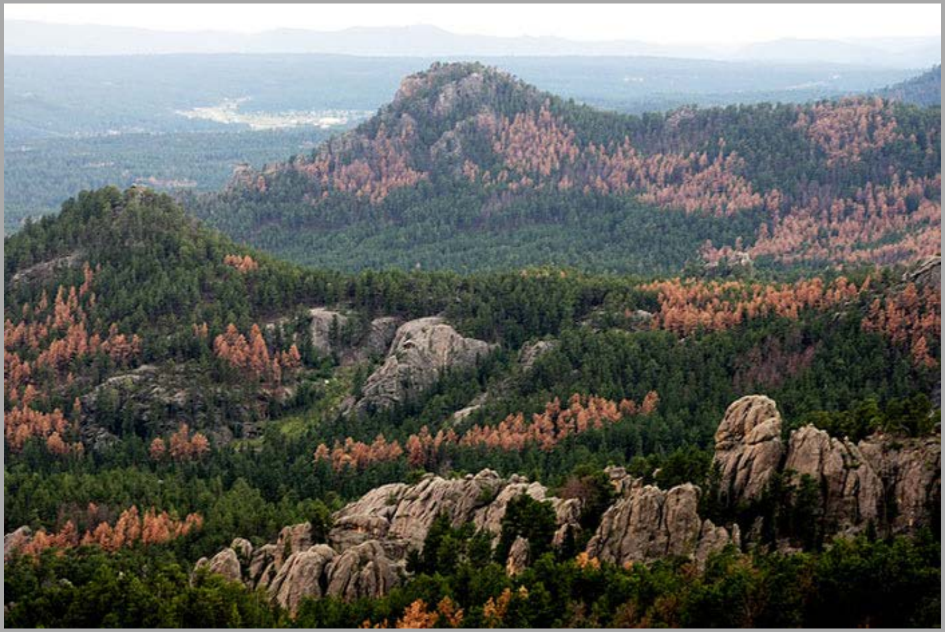
Fire

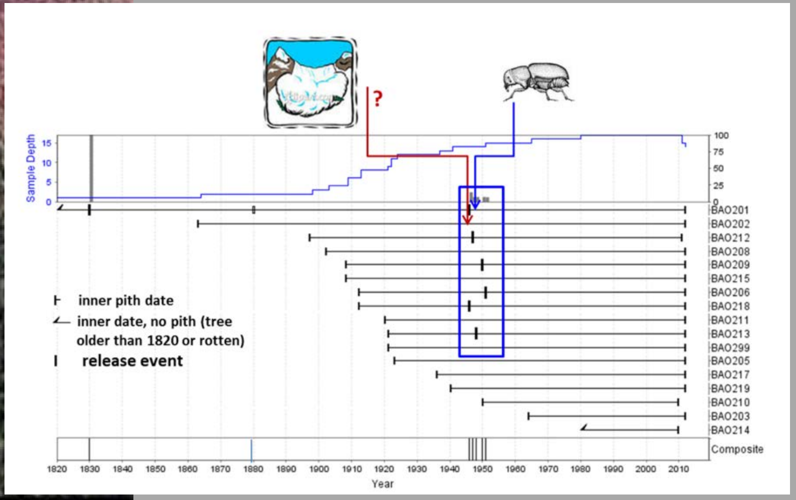
- **Charring may be absent**
- **Injury encompasses more than 1 ring**
- **Injury to rings formed pre-event**
- **Cell formation impaired in event year**
- **Heat injury extends around more circumference than physical injury**
- **Resin duct response varies by species**

Insects

- **Usually injury encompasses 1 year with little or no injury to pre-attack rings**
- **Wound response, but cell growth is otherwise normal**
- **No or minimal injury extending to greater circumference than chewing damage**
- **Resin duct response varies by species**

Outbreak intensity varies in time & space.





Outbreak intensity varies in time & space

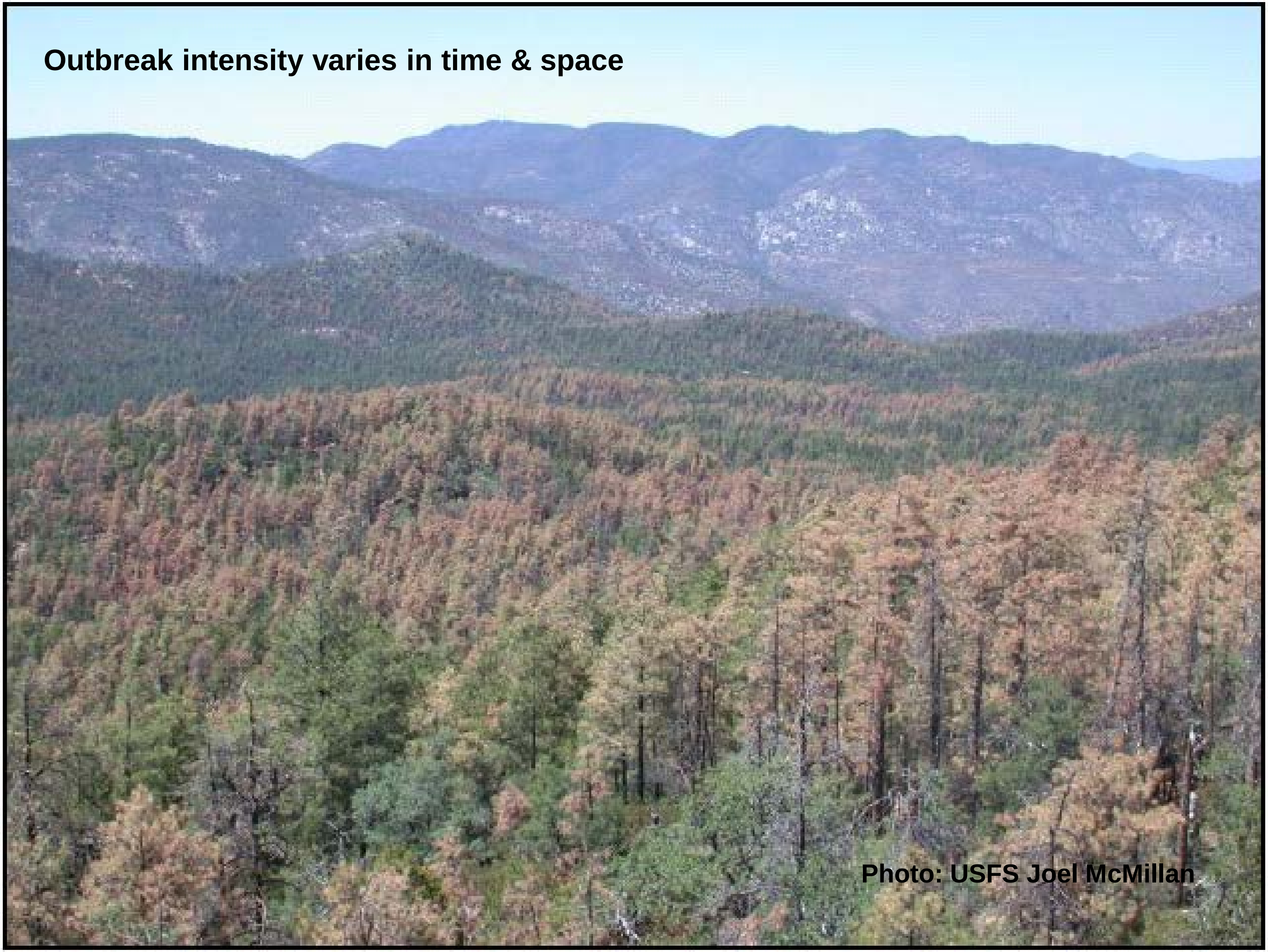
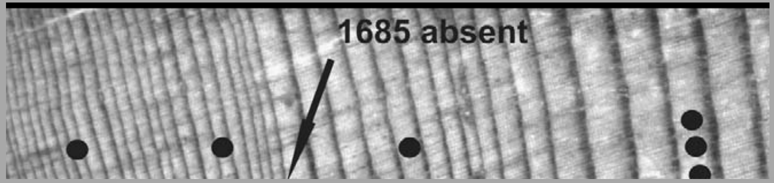


Photo: USFS Joel McMillan

Bark beetle signals do not make the material undatable

- Most investigators recognize a disturbance event
- Date on both sides of the event
- Do not assume fire
- Seasonality (& EW, LW) varies by species
- Often associated with:
  - Drought & other climatic factors
  - Changes in water table depth
  - Defoliation
  - Blow-down, avalanches
  - Over-stocked stands
  - Affects sensitivity, coefficients, & correlations

Breen & Baisan



Common tree-ring signals related to bark beetles:

- Growth surges
- Abrupt growth surges
- Imbedded small scars
- Staining fungi
- Orange wood
- Abundant snags & logs

Dendroecologists & Dendroentomologists

<u>**Non-host correction procedure for defoliator chronology reconstruction**</u>

Insect species are often host-specific

- **Western spruce budworm feeds on true firs and Douglas-fir, but not pines**
- **Pandora moth feeds on pines but not Douglas-fir or true firs**
- **Dated, measured series are standardized to common variance and subtracted one from another**
  - **Removes climate variability**
  - **→ "corrected" indices (insect signal + noise)**
- **Investigator applies rule set to infer outbreaks**