Individual Tree Growth and Responses

ESRM 323

Smith, et al. Chpt. 3

Influences on Growth Responses

- Capability of the Species (Genetics)
- Growing conditions (Environment)
- These two things interact (G x E)

Environmental Factors

- Climatic
  - air temperature, precipitation, wind, solar insolation, etc.
- Soil
  - physical, chemical, moisture holding capacity, micro-organisms
- Topography
  - slope, elevation, aspect, …
- Competition
  - other trees (both inter- and intra-specific), lower canopy vegetation, animals, …

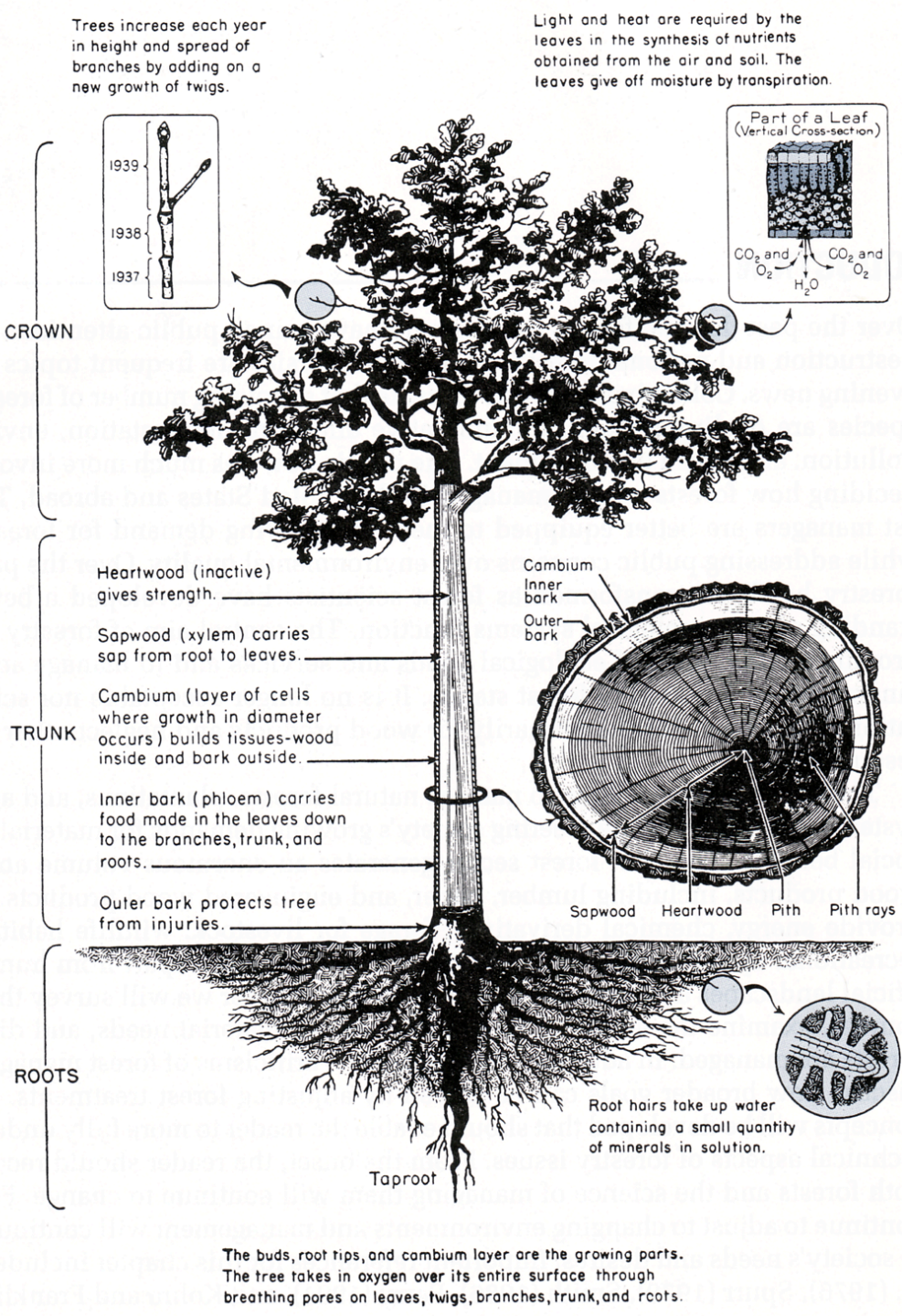
Starting Points

- Though treatments are prescribed for the stand, silviculture comes down to manipulating the processes of individual tree growth
- We treat the stand by doing things to individual trees
  - We manipulate the growing space
    - Spacing
    - Thinning
    - Pruning

What We Will Learn

- Basic tree physiology and growth interactions
- General responses to changes in growing space
  - Too much
  - Too little
- We will be covering these somewhat simultaneously

All tree parts act together to produce carbohydrates



Crown (Foliage) is the productive factory of the tree

- Two principal ‘growth habits’
  - Deliquescent (aka decurrent)
    - Growth is phytocentric- ‘toward light’
  - Excurrent
    - Growth is geocentric ‘from the center of the earth’
- Crown above crown closure horizon is the most productive
- Leaves produce (photosynthesize) carbohydrates for respiration and growth

Trunk (stem) provides physical support for crown

- Contains the conductive tissues
  - Xylem
    - Active xylem (sapwood) transports water / nutrients from roots upward
    - Inactive xylem (heartwood) functions mainly for strength
  - Phloem transports sugars / carbohydrates from leaves in the crown to other tree parts
- Outer bark (not just on trunk) protects tree

Roots anchor tree, providing support, water, nutrients

- Roots expand and extend more quickly than the crown
  - Primarily because they don't have the structural limitations of the above ground growth
- Roots intermingle and compete with the roots of other plants
  - Roots (fine) supply the water and nutrients to the foliage
  - Some grafting may occur (*Ulmus americana, Pseudotsuga menziesii)*

All tree parts act together to produce carbohydrates

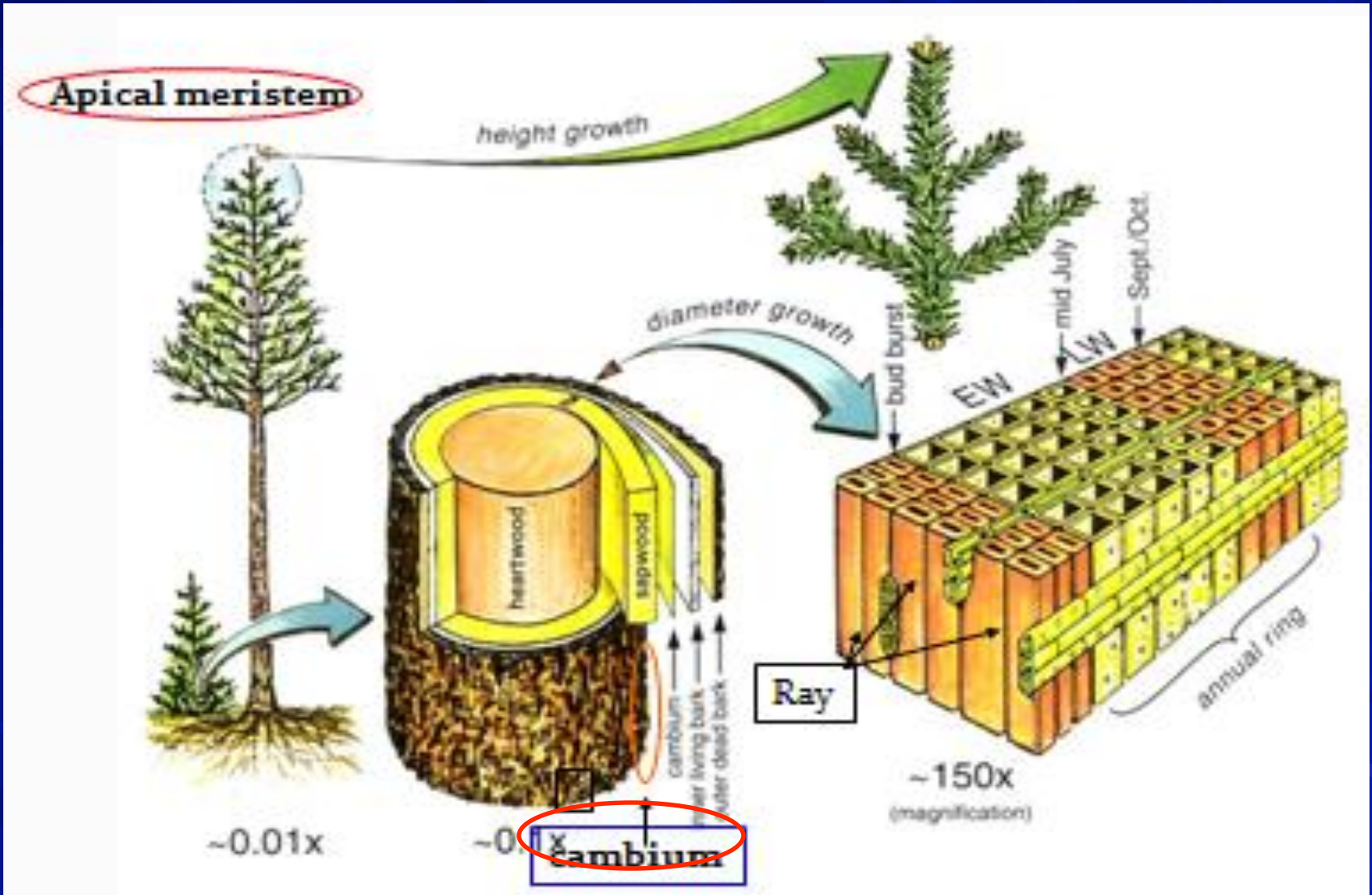
When a competitor dies, a healthy, neighboring tree experiences increases in:

- Water and nutrients
  - Roots of "winner" pick-up unused H_20 and nutrients.
  - Causes Prompt Growth Acceleration (Diam., Height)
- Foliage (amount) and Crown (size)
  - Delayed reaction but have the largest, long-term impact

All tree parts act together to produce carbohydrates

- Foliage (crown) is the productive factory of the tree
- Stem / trunk supports tree, conducts water & nutrients
- Roots anchor tree, take up water & nutrients
- The tree then needs to allocate (distribute) these carbohydrates to different functions

Growth Functions



Question

What is the main objective of an individual tree?

Answer

Reproduction

Dormancy (cessation of growth)

- Definition: time when growth (cell division, enlargement) does not occur.
  - ✓ In temperate and sub-arctic zones, winter can be lethal to most plants and animals.
  - ✓ Drought can also be lethal
  - ✓ Many animals are mobile and can escape.
  - ✓ Trees are not mobile (sessile), and cannot escape.
  - ✓ Dormancy = adaptation enabling plants to *endure winter and drought*
- Two types of dormancy
  a. "true" dormancy
  b. "imposed" dormancy

a. True Dormancy "winter rest"

- Physiological state in which trees, predisposed to grow, will not do so regardless of environmental conditions.
  - ✓ Genetically "hard-wired" into the tree.
  - ✓ Almost all temperate zone perennial plants exhibit true dormancy as an adaptation to endure winter conditions

- What signals produce true dormancy?
  - ✓ Day length (photoperiod) begins to shorten in late June.
  - ✓ Phytochrome (a pigment) senses the length of darkness
  - ✓ Phytochrome acts at the gene level to signal plants to prepare for winter (go dormant).

Release of true dormancy → initiation of spring growth

- Dormancy in Douglas-fir is released after a prolonged period of exposure to low temperatures (chilling).
  - "chilling requirement" →adaptation to prevent growth during a mid- winter warm spell.
  - As chilling time accumulates, the intensity of dormancy weakens

- Spring growth ("bud break") can start only after the chilling requirement is met
  - actual timing of bud break and resumption of growth depends on Spring temperature

b. Imposed dormancy "quiescence"

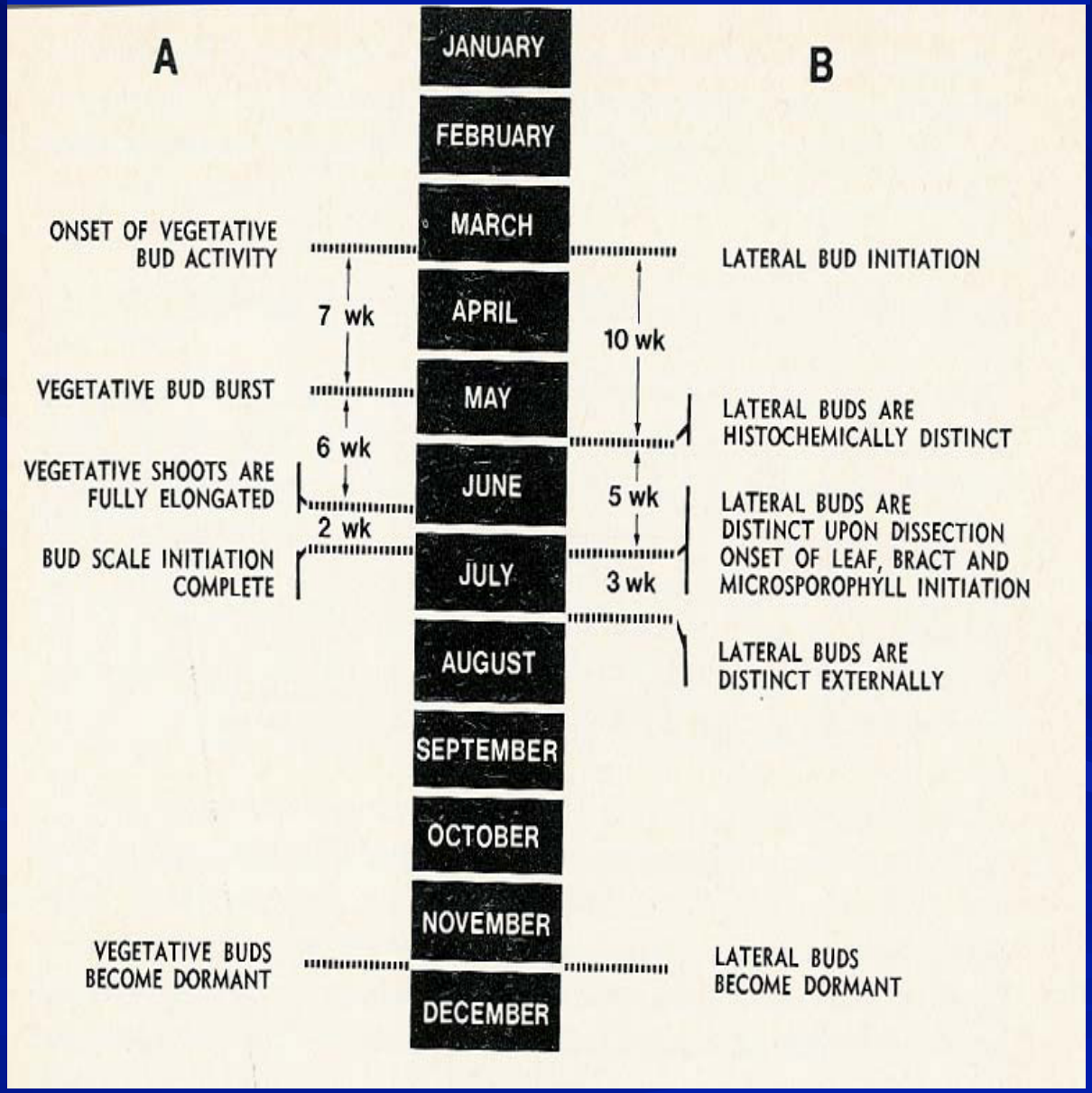
- Temporary growth cessation due to adverse environment
- Ex: summer drought → soil moisture deficit
  - ✓ Growth may resume with return of rain → may result in **<u>lammas shoots, false rings</u>**, etc.

- Other causes → insect defoliation, late spring frost

- This is **not true dormancy**

- Silviculture can reduce/remove imposed dormancy.
  - ➢ If competition, poor soil, etc. causes cessation of growth due to water limitation, thinning can help alleviate by reducing competition and extending the supply for others

Growing Season (Allen & Owens 1972)



Tree Function Priorities for Carbohydrate Allocation

- Immediate Survival First (1)
  - Respiration (metabolism) first and foremost, always
  - Fine root and foliage renewal (2)
    - Fine roots pick up water and nutrients, and foliage provides the ‘power to run the tree’ (factory)
    - The greater the crown surface area, the greater the amount of carbohydrate left for growth

Tree Function Priorities for Carbohydrate Allocation

- Reproduction (takes priority when occurs)
  - Flowers and seeds (at intervals)
    - During active seed years both height and diameter growth are reduced
    - Possible foliage reduction

Tree Function Priorities for Carbohydrate Allocation

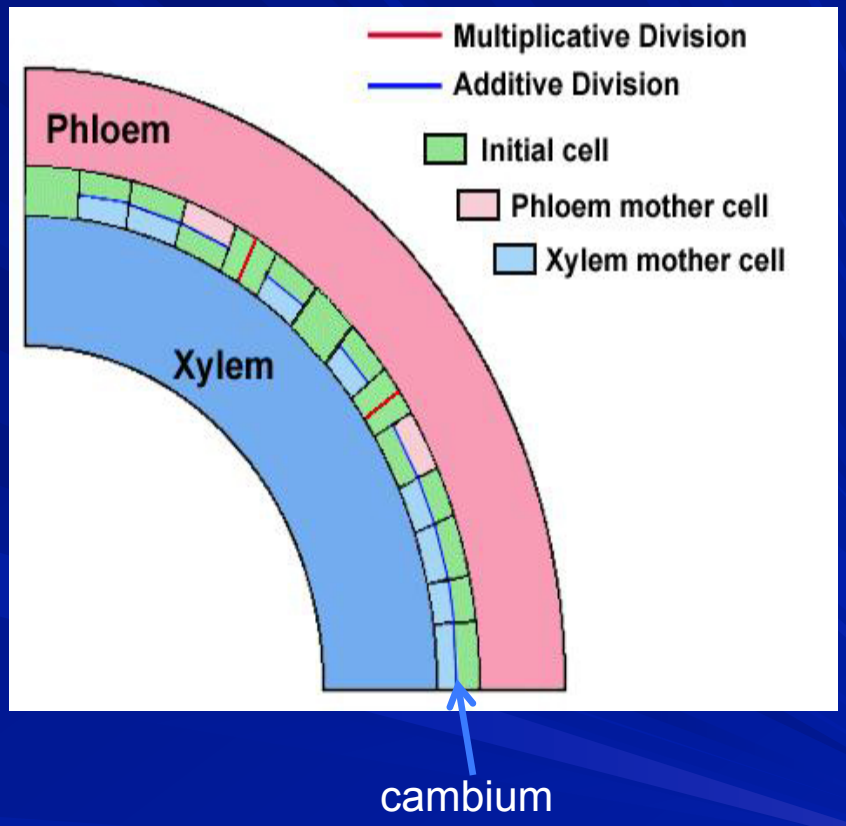
- Intermediate Survival (3)
  - What foresters call "Primary" growth
    - Height of terminal and length of lateral branches
      - In spring apical buds activate
      - Cells in apical meristem divide to produce shoot elongation ➔ generally done by late June
      - Apical meristems produce "growth regulators" influencing growth (apical control) elsewhere along the stem
    - Root extension
    - Renewal of phloem (getting carb's from leaves to roots)

Tree Function Priorities for Carbohydrate Allocation

- Long Term Survival (4)
  - Radial growth ("Secondary" Growth)
    - Adding xylem (Getting water & nutrients from Roots to Leaves)
    - Adding phloem (getting "food" from Leaves to other tree parts)

Diameter (radial) Growth

- Cambium produces
  - wood (xylem)
  - bark (phloem) cells
- Cambial activity follows resumption of bud activity in spring.
  - Growth regulators from apical meristems affect
    - ✓ rate of division
    - ✓ subsequent wood cell characteristics
- Remains active until temporary or true dormancy occurs



Tree Function Priorities for Carbohydrate Allocation

- Developing resistance (5)
  - to insects, diseases
    - Resins and other chemicals
      - Some secondary products may take priority over others

- Each function requires a higher level of respiration than the one before it

Tree Function Priorities for Carbohydrate Allocation

- The products we as people are most interested in (xylem in the stemwood) are not high on the tree's list of necessities
- Typically, in a healthy tree, a "layer" of xylem is laid down over the entire stem, forming a "sheath" of wood

Stem Form

Something we care about and the trees don’t

Tree Shape (stem form)

- Develops as a response to mechanical loading
  - Vertical load, i.e., Weight of the above ground mass
  - Horizontal load, i.e., pressure of fluid (air) pushing against tree

Tree Shape (Stem Form)

- Annual layer of wood laid down is not uniform from tip to base:
  - In Thickness
  - In Density
  - In Strength
  - In anatomical structure
- Width of ring at given height is affected by
  - Circumference at that height
  - Volume of wood put on at that height

Tree Shape (Ring width)

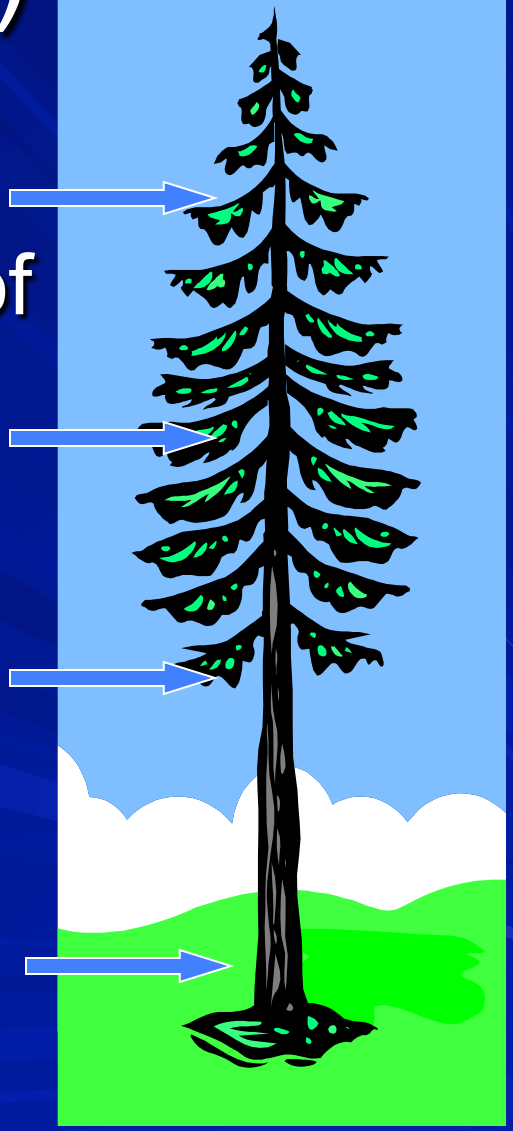
- Ring width is affected by the circumference of the tree stem
  - Even if volume growth is constant below the crown, rings get thinner because the wood must be spread around an ever bigger circle

Tree Shape (Ring width)

Diam (in.)	Radius (ft.)	A (ft^2)	Diam Diff
4.282	0.178	0.100	
6.056	0.252	0.200	1.774
8.564	0.357	0.400	
9.575	0.399	0.500	1.011
20.084	0.837	2.200	
20.535	0.856	2.300	0.451
29.973	1.249	4.900	
30.278	1.262	5.000	0.304
39.939	1.664	8.700	
40.168	1.674	8.800	0.229

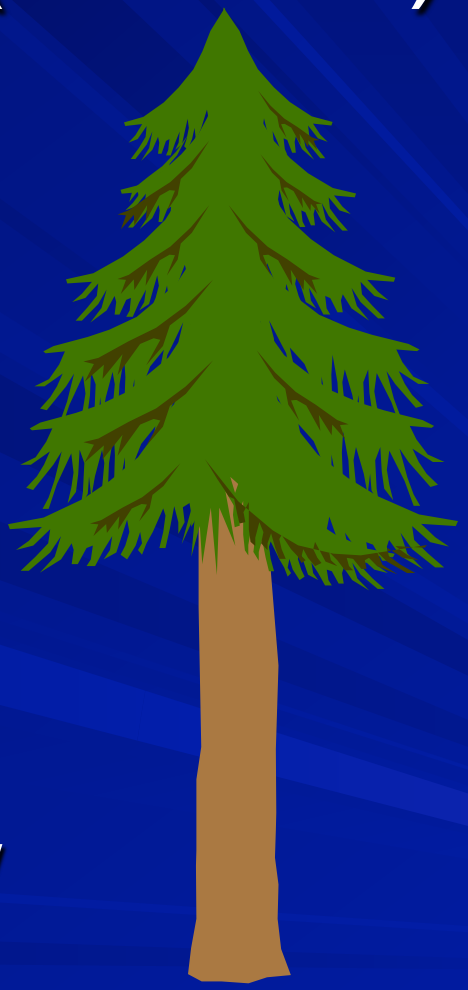
Tree Shape (Volume)

- Volume growth of wood at any point is proportional to amount of foliage above that point
  - Volume growth on a stem is a combination of distance from carbohydrate source & mechanically controlled response to bending

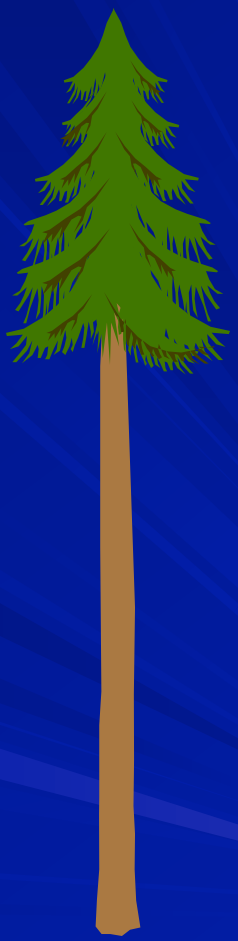


Tree Shape (Volume)

- Rate of volume accumulation on stem:
  - Open grown trees
    - increasing below crown
  - Main canopy trees
    - constant below crown
  - Low vigor trees
    - decreasing (or zero) below crown



Wide initial spacing



Narrow initial spacing

Stem From (Volume)

- Increasing the growing space available to a tree (via thinning out competitors)
  - Causes the crown to expand
    - Increases volume increment along the stem
      - Lower branches may increase too.

Trees Respond to Growing Space Manipulations

Impacts of increasing growing space

- Crown impacts
- Diameter impacts
- Height impacts

Impacts on Diameter

Has a Thinning been successful if there is a prompt transition from narrow rings to wide rings on the residual trees?

Answer

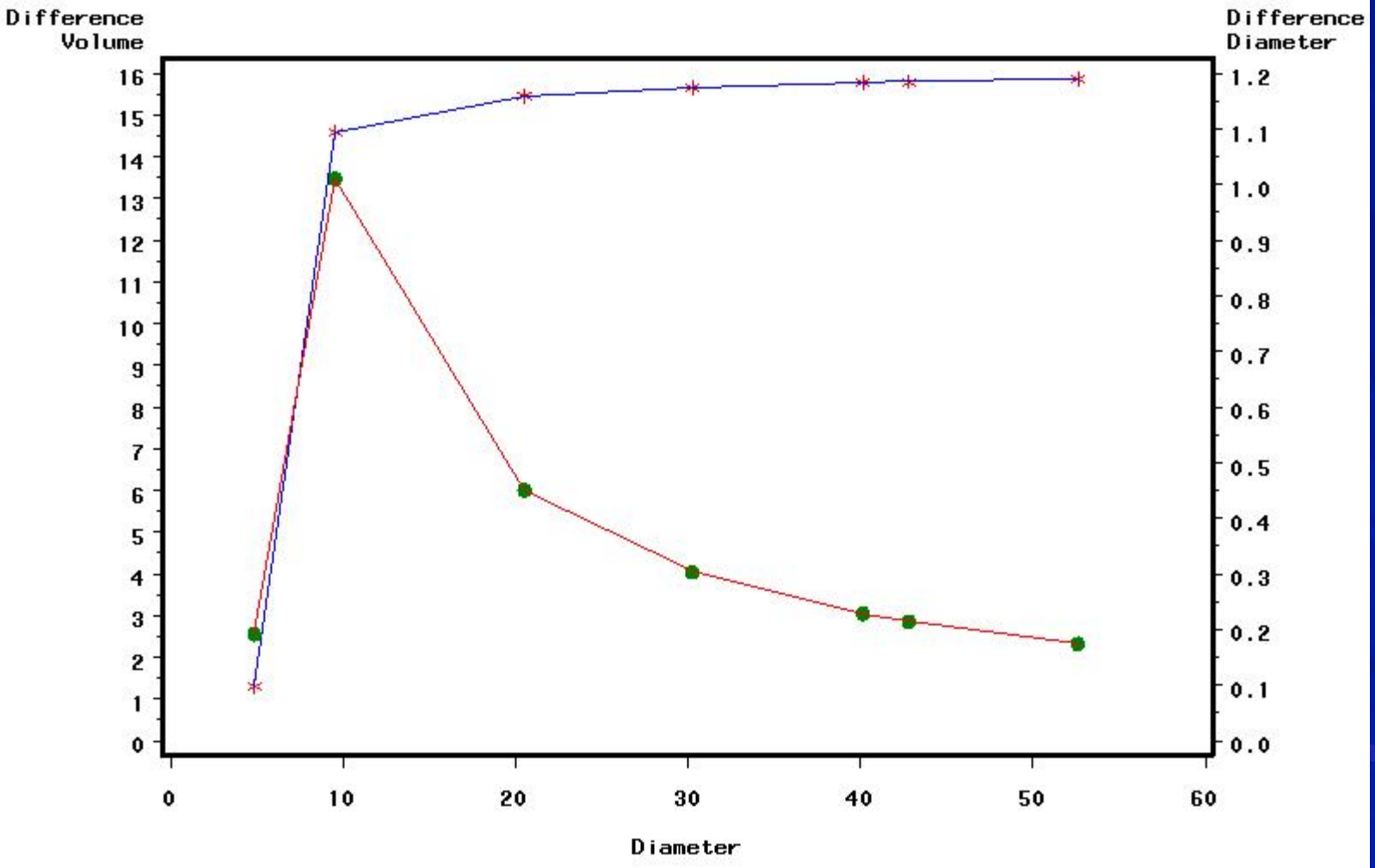
- Has a Thinning been successful if there is a prompt transition from narrow rings to wide rings on the residual trees?

Not really, it shows that thinning was late

  - Volume growth may actually increase as ring width slowly declines.

Dia (IN)	Radius (FT)	Area	Length	Volume	Dia Dif	Vol. Dif
4.69	0.20	0.12	16	10.87		
4.88	0.20	0.13	16	12.19	0.192	1.322
8.56	0.36	0.4	16	50.16		
9.57	0.40	0.5	16	64.76	1.011	14.598
20.08	0.84	2.2	16	323.07		
20.54	0.86	2.3	16	338.52	0.451	15.448
29.97	1.25	4.9	16	743.67		
30.28	1.26	5	16	759.34	0.304	15.672
39.94	1.66	8.7	16	1341.63		
40.17	1.67	8.8	16	1357.42	0.229	15.787
42.60	1.78	9.9	16	1531.20		
42.82	1.78	10	16	1547.00	0.215	15.808
52.44	2.19	15	16	2339.10		
52.62	2.19	15.1	16	2354.97	0.175	15.869

Decreasing Diameter Growth and Increasing Volume Growth



Source: I made it up April 14
After Lab and Supper

adh

Impacts on Height

Does thinning affect height growth?

- Does thinning affect height growth?
  - Not so you could tell …
    - Trees ‘race for the sky’ at the expense of their neighbors
      - The speed of the race is based on site quality (site index)
        - Remember, after breathing, eating (respiring), and reproducing, height and crown growth occur
  - Trees that are isolated, exposed, or open-grown may have reduced height growth, cp. within a stand
    - Tree allocates more to lateral expansion than vertical
  - Very high density stands also show a reduction in height, cp. with moderate to low density
    - Due to expenditures on respiration, fine root growth

Indicators of Tree Response Potential

- Live Crown Ratio (LCR): proportion of the tree stem that is in the living crown (length basis)
  - Indexes the ability of crown to nourish the rest of the tree
    - Highly correlated to ratio of photosynthetic to aphotosynthetic surface area
    - < 30% diameter growth significantly suffers
    - < 20% height growth significantly suffers
    - If really low (<10%?) the tree will probably die

Impacts of sudden increase in growing space: small-crowned trees

- Increased risk of mortality due to:
  - Insect attack
  - Sunscald
  - Death by cutting a large root grafted tree
  - Increase in respiration (x 2 for each 10 Deg. C increase)

Indicators of Tree Response Potential

- Height/Diameter ratio (H/D): Ratio of height to DBH using common units
  - Indicates how well the crown nourished the stem in the past
  - Dominant trees will have small(er) H/D ratios
  - Overtopped will have large(r) H/D ratios
  - H/D ratios in excess of 90 - 100 indicate mechanical instability

Tree Growth in more Detail

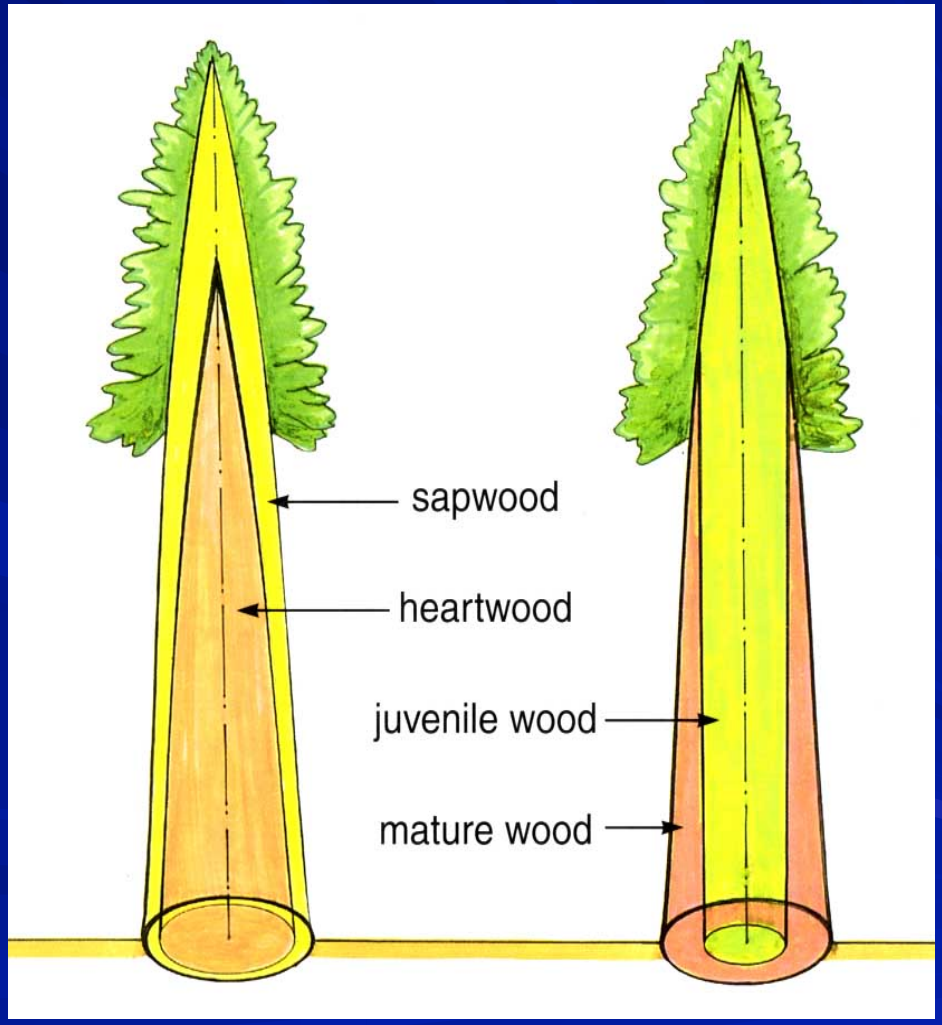
- Layer of wood laid on annually is not of uniform structure & density
  - Within growing season variation
    - Early wood
      - Beginning of growing season
        - Water conduction
    - Late wood
      - Later in growing season
        - Mechanical

Tree Growth in more Detail

- Layer of wood laid on annually is not of uniform structure & density
  - Vertical position variation
    - Juvenile wood (a.k.a. “Crown wood”)
      - Lower density
      - Atypical structure (compression / tension wood)
    - Mature wood
      - Higher density
      - Typical structure
- Combinations of juvenile / mature with early / late wood proportions determine the strength of the wood

JW / MW vs Heartwood (HW) / Sapwood (SW)

- SW: outer rings involved in transport of water & nutrients
- HW: old SW that is inert
- JW: inner rings with generally undesirable properties
- MW outer rings with generally desirable properties
- SW/HW and JW/MW overlap in all combinations in older trees
- A very young tree only has JW that is also SW



Thinning Response Detail

- Timing of a thin matters
  - A surviving tree will put on more of the wood it is growing at the time of the thin that kills its competitors
- Thinning may be contraindicated by the properties we want the leave trees to have
  - Delays natural pruning
    - May increase size of lower branches
    - May increase the number of lower branches
      - May cause epicormic branching
- Pruning may be just the thing
  - Reduces the number of loose knots

Pruning in Detail

- Trees require branches, but only the live ones are any good to it
- Dead, lower branches are sometimes removed to give the tree properties we like
- There are three types of pruning
  - Natural
  - Artificial
  - Green

Natural Pruning

- Most trees in the forest are naturally pruned—also called self-pruning
  - Branches die back due to:
    - Low light
    - Wind
    - Contact with branches of neighbors – crown shyness
  - The greater the stand density, the smaller the branches and the sooner they're shed

Natural Pruning

- Occlusion: covering the short stub left by the dead, shed branch with living tissue.
  - Like a post in a stream being covered by rising water
    - Depends more on the rate of stream rising, not so much on the diameter of the post

Artificial Pruning

- We can't always get what we want from a stand with density manipulation alone
  - Training effects are sometimes inadequate for desired wood quality
  - Pruning can decrease the occurrence of loose knots
- Timing
  - Too early and we may choose losers
  - Too late and we won't have the volume of clear wood others want
  - Wait to prune until at least the terminal leader exceeds desired log length

Artificial Pruning

- Artificial Pruning Economics
  - Makes sense when there is a premium for clear wood of a specific species
    - Cabinet work, furniture, high grade surface veneer, interior finish
  - Easy to prune up to about 10 ft. ~ what a person can reach form the ground; past that it gets very expensive.
  - Usually limited to a few trees per acre, usually the dominant trees (leaving “followers” unpruned)
    - Heal faster, and grow faster, more clear wood

Artificial Pruning

- Artificial Pruning Economics (con't)
  - Premium not there for construction lumber
    - Knots do weaken the wood
      - Cheaper to use bigger timbers
    - Changing now with short rotation times and widely spaced stands

Artificial Pruning

- How to do it:
  - Prune in one or two lifts
  - Couple pruning with thinning to maintain good diameter growth rates
    - FIRST THIN, then PRUNE
      - Pruning is very expensive, you don't want to waste the work by cutting down pruned trees during the thin
      - Avoids logging damage to now expensive pruned trees
  - Prune during the dormant season when bark is tight and detrimental fungal spores are few

Green Pruning

- Removing Branches while they are still live
  - Widely spaced stand will produce highly tapered trees with large, live branches
    - Prune to control taper
    - Green pruning will slow / halt development of juvenile wood below the height of the lift
  - Excessive green pruning may cause sun scald in widely spaced stands, esp. in thin barked species
  - May also cause epicormic branching, esp. in species with lots of dormant buds
    - Spruce, Douglas-fir, and true firs

Two Miscellaneous Bits

- When the terminal shoot is killed
  - Race for the sky continues
    - Lateral replaces terminal
    - If one or more laterals turn up we can get
      - Crook, Fork
- Lammas Growth
  - Sudden expansion and growth of a bud late in the growing season
    - Can be either a terminal shoot or a lateral shoot
    - If lateral → ramicorn branch

Ending Points

- We treat the stand by doing things to individual trees
  - We manipulate the growing space
    - Spacing (juvenile, or “pre-commercial”)
    - Thinning
    - Fertilizing
    - Pruning, irrigating (less often)
- Outcomes we can expect are mediated by
  - Genetics
  - Environment
  - G x E