Growth and Yield

Lecture 8 (4/27/2017)

Overview

- Review of stand characteristics that affect growth
- Basic Stand Growth Terminology
  - Yield curve;
  - Yield;
  - Annual increment;
  - Periodic Annual Increment (PAI);
  - Mean Annual Increment (MAI);
  - Compound interest rate of growth.
- Growth calculation example

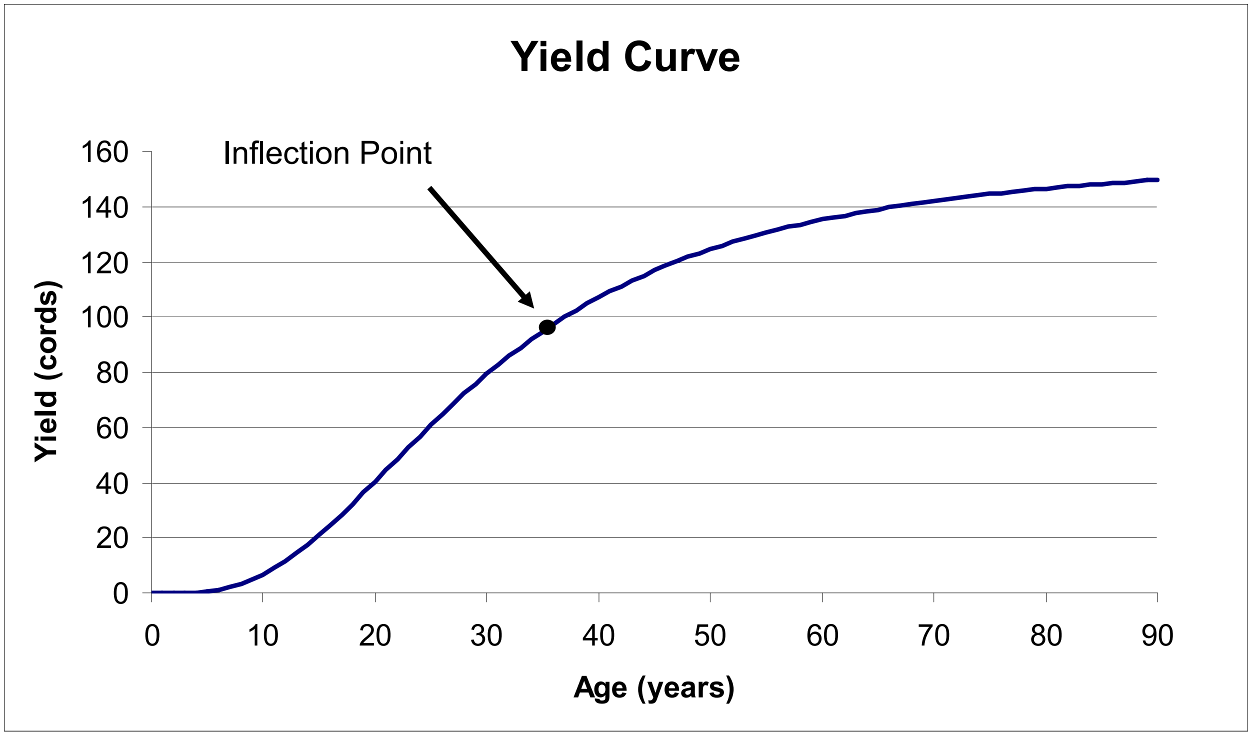
Stand characteristics affecting growth

1. Species composition
   - Affects both growth and types of products
   - Forest/cover types
2. Age
   - Often not well-defined
   - DBH or stand volume is often used as a proxy
   - Control: by harvesting
3. Site quality
   - Measured by *site index*: projected height of the dominant and co-dominant trees of a given species at an index age
   - Site Index is best but a very inexact measure
   - Control: by fertilization

4. Density (or stocking)
   - Measures: Basal area, number of trees per acre or volume per acre
   - Control: by thinning
5. Competition
   - Competition from undesirable vegetation
   - Competition between individual trees (density)
   - Measures: crown ratio, ratio of tree diameter to stand quadratic mean diameter
   - Control: release treatments, prescribed burning

Stand Growth Terminology

- Yield (Y_a) = The volume of usable wood fiber per unit area at age *a*
- The yield curve
  - The yield of wood from a stand at various harvest ages



Stand Growth Terminology cont.

- Annual Increment (annual growth):

$$G_a = Y_a - Y_{a-1}$$

- Periodic Annual Increment:

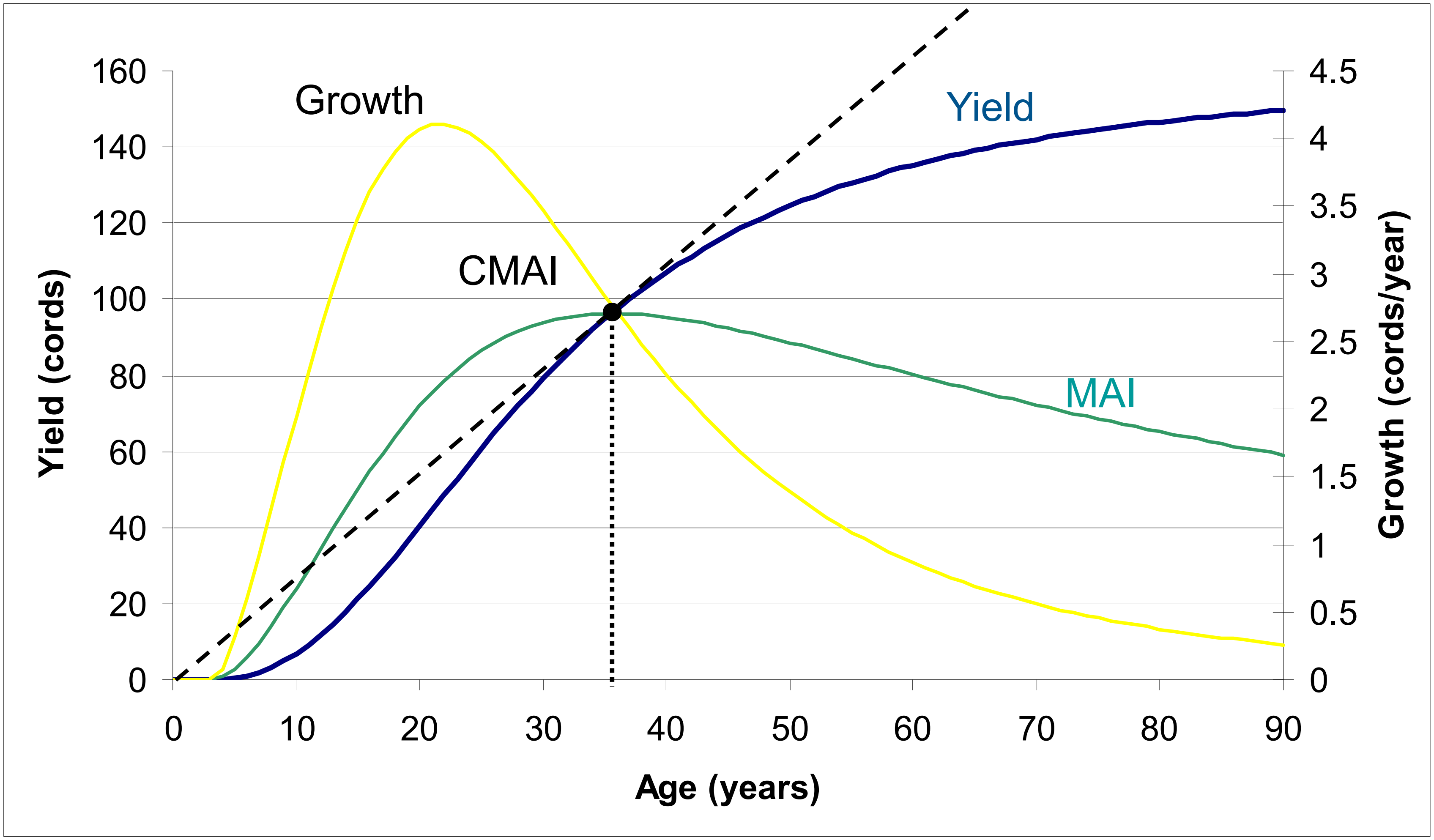
$$PAI_{a_1,a_2} = \frac{Y_{a_2} - Y_{a_1}}{a_2 - a_1}$$

Stand Growth Terminology cont.

- Mean Annual Increment: $MAI_a = Y_a / a$
  - MAI measures the average productivity of a stand over its lifetime;
  - The age at which MAI is max is called the Culmination of MAI (CMAI) = optimal biological rotation age;
  - The optimal biological rotation age ignores costs
- Compound Interest Rate of Growth:
  - The average compound volume growth between a1 & a2

$$r^{Y}_{a_1,a_2} = \left[\sqrt[a_2-a_1]{\frac{Y_{a_2}}{Y_{a_1}}} \right] - 1$$

Yield, growth and MAI



Example

Age	Yield (cords)	Yield (Age-1)	Annual Increment	PAI (Age-5 to Age)	MAI	Comp. Int. Rate
20	40.440	36.373	4.067	---	2.022	---
25	60.745	56.768	3.977	4.061	2.430	0.085
30	79.201	75.733		3.691	2.640	
35	94.664	91.823	2.840		2.705	0.036
40	107.077	104.822	2.255	2.483		0.025

Stand establishment, thinning and other intermediate treatments

Financially sound treatments

- The difference between the present value of the costs end benefits that occur with the treatment and the present value of the costs and benefits that occur without the treatment must exceed the present value of the costs of the treatment.

Stand establishment, thinning and other intermediate treatments

Decisions in even-aged stand management

- The rotation decision (LEV, FV)

- The stand establishment decision
- Thinning decisions
- Other intermediate treatment decisions

The integration of the stand management decisions with forest level decisions is necessary!

Intermediate treatments

- <u>Silvicultural treatments</u> change the future course of the stand;
- The redirected future stand states provide <u>more desirable products and services</u> than those that would occur without the treatments;
- <u>Financially sound treatments</u>: The difference between the present value of products and services that occur with the treatment and the present value of the costs and benefits that occur without the treatment must exceed the present value of the costs of the treatment.

Stand establishment

- Deer fencing in Northeast
- Site preps:
    - Prescribed burning
    - Herbicide
    - Mechanical treatments
- Leaving seed trees
- Shelterwood
- Winter harvesting
- Planting
    - natural vs. artificial regeneration

Adequate quantity and quality of regeneration

Thinning is

- done to:
  - Capture mortality,
  - Improve spacing,
  - Increase the growth rates of a select set of trees by concentrating the resources available for them (these trees should be selected based on their potential to increase in value).

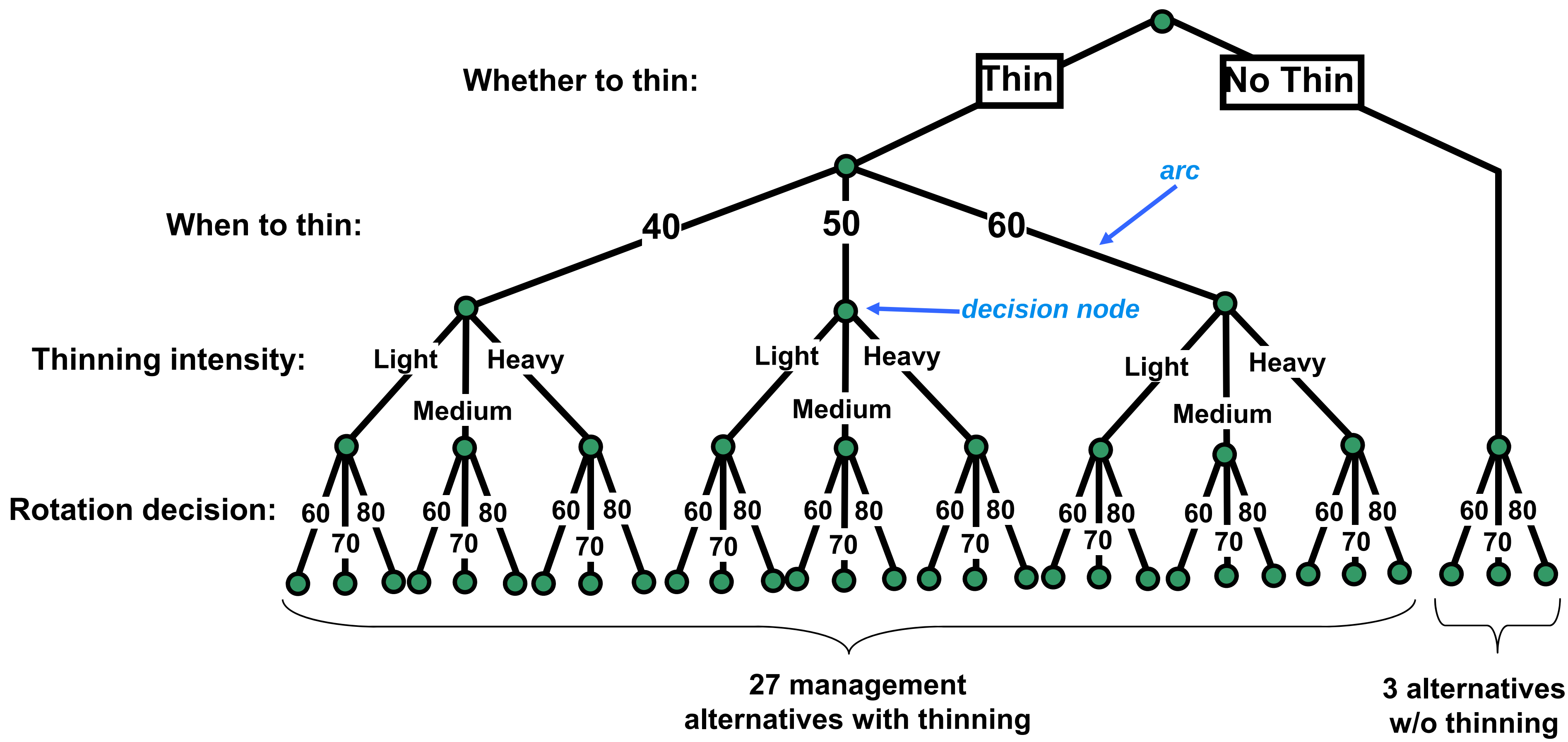
Other intermediate treatments

- Release treatments (mechanical, chemical or fire);
- Fertilization
- Irrigation
- Prescribed burning

Decision analysis

- Should a certain treatment be applied?
- If it should, when and how should it be implemented?
- Example: decisions must be made on the frequency, intensity and timing of thinnings.
- One treatment decision depends on other stand management decision as well (e.g., the rotation and thinning decisions depend on the planting density).

Example: a decision tree for stand management



Note: a systematic, sequential decision technique, called dynamic programming can be used to solve decision problems like this

The sawtimber/pulpwood price ratio and three basic thinning strategies

Sawtimber/pulpwood price ratio	Thinning strategy	Explanation
1.) High	Sawtimber in unthinned stands, very long rotations	(1) thinnings would be pre-commercial, (2) long rotations because no thinning would hasten sawtimber-sized trees, (3) low planting density or natural regen (w/o intermediate returns, the cost of carrying establishment costs is too high), (4) extensive management, (5) examples: oak-hickory, northern hardwood in the Northeast.
2.) Medium	Both pulp and sawtimber is produced in thinned stands	(1) Good markets for both pulpwood and sawtimber, (2) multiple thinnings, (3) medium rotation length because trees reach sawtimber size sooner with thinnings, (4) high planting density, (5) examples: pine in the Gulf States and Douglas fir in the Pacific Northwest
3.) Low	Pulp in unthinned stands, very short rotations	(1) pulp production dominates, (2) high planting densities to maximize the utilization of site resources, (3) pulpwood production doesn't benefit from thinning, (4) management intensity depends on prices, (5) pine in the Southeast or aspen in the Lake States

Summary

- Economics drives thinning and stand establishment decisions
- <u>Example:</u> better pulpwood markets might shift management from sawtimber only model to sawtimber/pulpwood model which would include thinning, shorter rotations and higher intensity management.