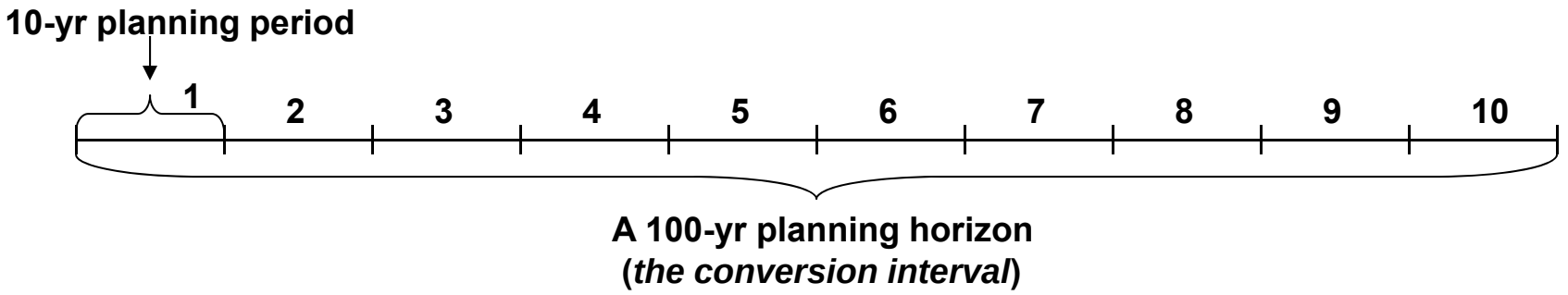
Forest Regulation Concepts

Lecture 11 (5/4/2017)

Planning periods and the planning horizon



Unregulated forest → **Regulated forest**

$$Since\ A_1 = A_2 = A_3 = \ldots = A_R \quad \Rightarrow \quad A_i = \frac{A}{R} \times n$$

Area in each age class

Rotation age

Period length

The annual harvest from a regulated forest

$$H_{Reg}^{Annual} = A_R \times v_R = \frac{A}{R} \times v_R = A \times \frac{v_R}{R} = A \times MAI_R$$

- The rotation age that maximizes MAI will also maximize the annual harvest
- Therefore, the age at which the MAI is maximized is sometimes considered the best age for regulating a forest

Selecting the regulation rotation

- The present value of the forest is maximized if it is converted to a forest regulated on the rotation that maximizes LEV;
- If a forest is regulated on the rotation that maximizes MAI, too much inventory will result;
- The inventory cost must be accounted for

Selecting the regulation rotation – *an example*

Age	Volume (cd/ac)	MAI (cd/ac/yr)	LEV ($/ac)
10	5		
20	16	0.8	
30	32	1.067	
40	55	1.375	
50	75	1.5	
60	90	1.5	
70	100	1.429	

Economic data:

- Stumpage price: $25/cd
- Stand establishment cost: $200/ac
- The real interest rate: 4%
- All prices and costs are assumed to increase at the rate of inflation

$$LEV_{30} = \frac{Y_{30} \cdot P - E(1+r)^R}{(1+r)^R - 1} = \frac{32 \cdot 25 - 200(1.04)^{30}}{(1.04)^{30} - 1} = \underline{\underline{\$67.45}}$$

The conversion period

- For a regulated forest: all stand-level management decisions must be selected by a prescription that maximizes the LEV
- During a conversion period: at least some prescription must be used that do not maximize the LEV for that stand

The Long Term Sustained Yield (LTSY)

- LTSY = The harvest from a regulated forest
- The LTSY indicates the amount of wood that can be harvested from a forest on a sustainable basis

Calculation the LTSY for a forest w/ one forest type and multiple site classes

- **Step1**: Determine the rotation age for each site class
- **Step2**: Calculate the MAI for each site class
- **Step3**: $LTSY = \sum_{s=1}^{S} [MAI_{R^*} \times A_S]$

- **Example**:

Site Class	Area (ac)	Optimal Rotation (R*)	Yield at R* (cd/ac)
I	4,200	35	41
II	5,600	45	46
III	3,500	50	48

$$LTSY = \frac{41}{35} \cdot 4,200 + \frac{46}{45} \cdot 5,600 + \frac{48}{50} \cdot 3,500 = \underline{\underline{14,004 cds / yr}}$$

Methods of Forest Regulation

- How to get from an existing forest with an unbalanced age-class distribution to a regulated forest?
- The *area* and *volume control* focus on cutting a target area (or volume) in each planning period

Area Control

- Cut and regenerate the same number of acres each year (or each period) as would be harvested if you had a regulated forest
- The regulated forest will be achieved within at least one rotation

Steps in Area Control

1. Calculate the desired rotation age for the regulated forest
   - The rotation that maximizes the LEV should be selected if the landowner's primary objective is profit maximization
2. Calculate the number of acres to cut in each period
   - Divide the area of the forest by the number of age-classes in the target regulated forest

Steps in Area Control cont.

3. Project the age-class distribution
   - Move the harvested acres to the youngest age class and move the unharvested acres up to the next age class
4. Calculate the harvested volume
   - Multiply the per-acre yield by the area harvested
5. Repeat Steps 3,4 until the forest is regulated

Example of Area Control

A 750-acre forest

Yield table and LEV

Age	Volume (cd/ac)	LEV ($/ac)
10	5	
20	16	-32.09
30	32	67.45
40	55	109.13
50	75	74.29
60	90	15.34
70	100	-42.16

Initial age-class distribution

Age Class	Acres
0-10	250
11-20	250
21-30	0
31-40	250

Target age-class distribution

Age Class	Acres
0-10	187.5
11-20	187.5
21-30	187.5
31-40	187.5

$$A_1 = A_2 = A_3 = A_4 = 750ac / 4 = \underline{\underline{187.5ac}}$$

Projecting the age-class distribution using area control

- What is the harvest target area? **187.5ac**

Initial age-class distribution

Age Class	Acres
0-10	250
11-20	250
21-30	0
31-40	250

Age-class distribution after 10 yrs

Age Class	Acres
0-10	187.5
11-20	250
21-30	250
31-40	0
41-50	62.5

Age-class distribution after 20 yrs

Age Class	Acres
0-10	187.5
11-20	187.5
21-30	250
31-40	125
41-50	0

Age-class distribution after 30 yrs

Age Class	Acres
0-10	187.5
11-20	187.5
21-30	187.5
31-40	187.5
41-50	0

Projecting the harvest volume

Age Class	Acres in each age-class at the beginning of each decade			
	0	10	20	30
0-10	250	187.5	187.5	187.5
11-20	250	250	187.5	187.5
21-30	0	250	250	187.5
31-40	250	0	125	187.5
41-50	0	62.5	0	0
Total Acres	750	750	750	750
Average Annual Cut (cords)				
Average Annual Net Revenue ($)				

•Stumpage price: $25/cd •Stand establishment cost: $200/ac

Yield table

Age	Volume (cd/ac)
10	5
20	16
30	32
40	55
50	75
60	90
70	100

Volume Control

- With Area Control, the harvest volume fluctuates during the conversion interval
- With Volume Control, the volume to be harvested is determined first
- The number of acres to be harvested fluctuates during the conversion interval
- Regulated forest is might not be achieved within one rotation length

Steps in Volume Control

1. Calculate the desired rotation age for the regulated forest;
2. Calculate the volume to be harvested in each year using one of the volume control formulas;
3. Starting with the oldest age class, calculate the number of acres that need to be cut from each age class to produce the target harvest volume;

Steps in Volume Control cont.

4. Project the age-class distribution forward one period by moving harvested acres to the youngest age class in the next period and unharvested acres up to the next age class;
5. Repeat steps 2 through 4 until the forest's projected age-class distribution is regulated.

The Hundeshagen Formula

$$H_t = \frac{H_{Reg}}{I_{Reg}} \times I_t = \frac{I_t}{I_{Reg}} \times H_{Reg}$$

where H_t = the volume harvested in the current period,

H_{Reg} = the volume harvested from a regulated forest,

I_{Reg} = the inventory volume in a regulated forest, and

I_t = the inventory volume in the current forest.

Calculating the Current Inventory Volume (I_t)

Age	Volume (cd/ac)	Age	Volume (cd/ac)
10	5	5	2.5
		15	10.5
20	16	25	24
30	32	35	43.5
40	55	45	65
50	75	55	82.5
60	90	65	95
70	100	75	100

Age Class	Acres	Inventory (vol/ac)	Inventory volume
0-10	250	2.5	625
11-20	250	10.5	2,625
21-30	0	24	0
31-40	250	43	10,875
TOTAL	750	N/A	14,125

$$I_t = \underline{14{,}125\ cords}$$

Calculating the Target Inventory (I_{Reg}) and Harvest Volume (H_{Reg})

Age Class	Acres	Inventory (vol/ac)	Inventory volume
0-10	187.5	2.5	468.75
11-20	187.5	10.5	1,968.75
21-30	187.5	24	4,500.00
31-40	187.5	43	8,156.25
TOTAL	750	N/A	15,093.75

$$I_{Reg} = \underline{15{,}093.75\ cords}$$

$$H_{Reg} = \underline{1{,}031.25\ cords}$$

Calculating the Harvest Target for the First Planning Period

$$H_t = \frac{I_t}{I_{Reg}} \times H_{Reg} = \frac{14,125}{15.093.75} \times 1,031.25 = \underline{965.06\ cd\ /\ yr}$$

Harvest target for the first planning period:

9,650.6 cords

Projecting the Age-class Distribution to Period 1

Age Class	Initial Acres	Acres after 10 years
0-10	250	
11-20	250	
21-30	0	
31-40	250	
41-50	0	

9,650.6/55=175.5 acres will need to be harvested from age class 31-40 to meet the target of 9,650.6 cords.

The Inventory Volume in the Beginning of the Second Period

Age Class	Acres	Inventory (vol/ac)	Inventory volume
0-10	175.5	2.5	438.75
11-20	250	10.5	2,625.0
21-30	250	24	6,000.0
31-40	0	43	0
41-50	74.5	65	4,842.5
TOTAL	750	N/A	13,906.25

$$H_t = \frac{I_t}{I_{Reg}} \times H_{Reg} = \frac{13,906.25}{15.093.75} \times 1,031.25 = \underline{950.12\ cd / yr}$$

Projecting the Age-class Distribution to Period 2

Age Class	Initial Acres	Acres after 10 years	Acres after 20 years
0-10	250	175.5	
11-20	250	250	
21-30	0	250	
31-40	250	0	
41-50	0	74.5	

The 41-50 age class will provide 75*74.5= 5,587.5 cords. We still need to cut 3,913.7 cords from the 21-30 age class. This translates to 3,913.7/32=122.3 acres.

Projected age-class distribution, inventory, annual cut and net revenues under Volume Control

Age Class	Acres in each age-class at the beginning of each decade				
	0	**10**	**20**	**30**	**40**
0-10	**250**	**175.5**	**196.8**	**204.8**	**181.3**
11-20	**250**	**250**	**175.5**	**196.8**	**204.8**
21-30	**0**	**250**	**250**	**175.5**	**196.8**
31-40	**250**	**0**	**127.7**	**173.0**	**167.2**
41-50	**0**	**74.5**	**0**	**0**	**0**
Total Acres	750	750	750	750	750
Inventory	14,125	13,906	13,890	14,316	14,600
Average Annual Cut (cords)					
Average Annual Net Revenue ($)					

•Stumpage price: $25/cd •Stand establishment cost: $200/ac

Yield table

Age	Volume (cd/ac)
10	**5**
20	**16**
30	**32**
40	**55**
50	**75**
60	**90**
70	**100**