Harvest Regulation with Selective Cutting for Natural Forest

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Abstract: The model of harvest regulation with selective cutting for natural forest is established. It is calculated using data of Taizhishan Forest Farm Administration Bureau in Hubei Province. The forest harvest regulation with selective cutting and forest harvest regulation with clear cutting are one kind of forestry optimization model, they integrate forest regulation's important decision-making question in the linear programming model optimization of decision-making track.

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Key words: Harvest regulation; Selective rutting; Natural forest

1 Secondary forest's age vector structures

The age vector structure of natural forest Taizhishan Forest Farm Administration Bureau is shown in Fig. 1.

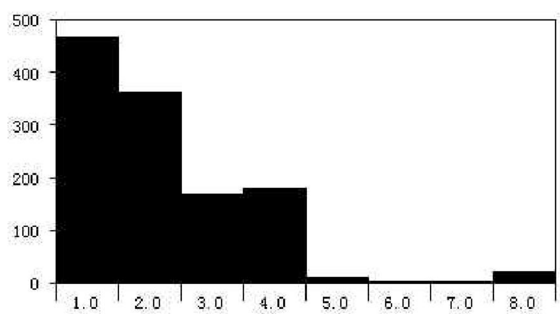

Fig. 1 Forest age vector structure of natural forests for Taizhishan Forest Farm Administration Bureau

Structure of volume per hectare of different ages for Taizhishan Forest Farm Administration Bureau is shown in Fig. 2.

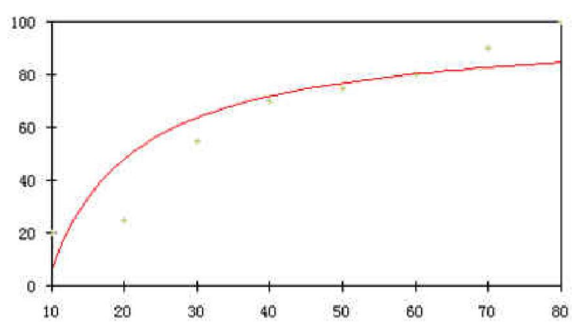

Fig. 2 Structure of volume per hectare of different ages for Taizhishan Forest Farm Administration Bureau

By Fig. 1, Fig. 2, it is shown that structure of natural forest age vector and volume per hectare of Taizhishan Forest Farm Administration Bureau are the quite low levels, this area population density is big, not only the long-term economic activity result primary vegetation already doesn't exist more, moreover the forest quality is in the inferior level. Natural forest of Taizhishan Forest Farm Administration Bureau is the low horizontal secondary forest. Why natural forest of Taizhishan Forest Farm Administration Bureau is the low horizontal secondary forest, That is a result which the people cut for a long time. Its overmatural forest also only has the volume of 100m3/hm2, it cuts the basis is specially so-called "the forest market is mature ". Its forest cannot wait till the forest quantity to pick maturely cuts. The forest stipulated which in the northeast forest region cuts the lowest diameter step is 16 cm, but here implement is 10-12 cm. The 10-12 cm at the young growth condition, how possibly is quantity is mature?

2 The concept of selective cutting in harvest regulation model

[The definition] In the harvest regulation model, continuously carrying on the selective cutting optimization choice to some stand, some stand which selects cutting by periods, cuts the part big forest, causes volume with the age drops, through retaining the wooden growth to restore to the selective cutting in the past condition, uses the time-gap becomes the selective cutting cycle. Also it is called tropical year (cutting cycle).

This definition explains that selective cutting is one sustainable cutting way, the selective cutting can cause stand volume decreasing with the age, but it limits to the range which forest can restored, it could be able to restore completely through some time. Generally speaking, stand in the selective cutting recovery period, because of the growth space release, the volume increment can have the acceleration. Fig. 3 is the computer simulation process of selective cutting.

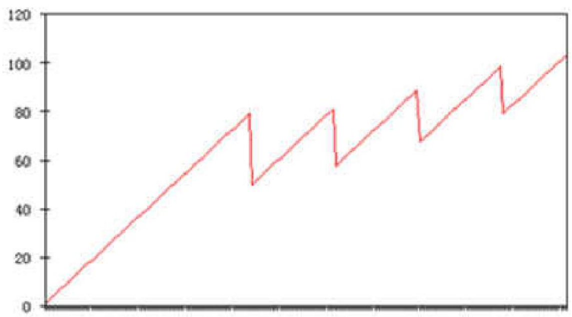

Fig. 3 Simulating process of selective cutting by computer

3 Selective cutting age of forest drop classics

The selective cutting caused the age of forest drop classics description is Tang Shouzheng in 1985 proposed in “Study Report in the National Timber Forest Resources Development Trend”:

[Definition]: May conceive stand to drop after the selective cutting for another age-class (this has been adopted by the northeast forest region the proper attention to both to cut down supports). Supposes the growth equation of volume per hectare is the vector:

$$V = (v_0, v_1, v_2, \ldots\ldots v_n) \quad (1)$$

After selective cutting, because of the selective cutting intensity ρ_j, volume per hectare becomes:

$$v_j = v_j \times (1 - \rho_j) \quad (2)$$

Therefore, it is equal to stand shifting to the L age-class, v_j nearby v_L that is determined by equation (3):

$$|v_L - v_j| = \min_{o \le r \le n} |v_j - v_r| \quad (3)$$

In other words: age-class L decreasing by selective cutting must find closest age-class of stand volume from the volume, it is the age-class which the selective cutting drops.

In the harvest regulation model, using the classical method to determine the selective cutting decreasing age-class is too troubles, the data collection also has the difficulty, therefore under condition of the selective cutting total decreasing tendency unchangeable, it simplifies for the linearity decreasing.

4 Stand age decreasing linearization of selective cutting

Supposes the selective cutting carried on L stand age-class, the selective cutting causes the age-class drop is possibly Y, along with the increasing of periods and the selective cutting continuation, the selective cutting possibly causes the age-class decreasing continuously.

Stand age decreasing caused by selective cutting has two boundary conditions: (1) When selective cutting intensity =0, y=L, that is age-class no decreasing, it is in the nature growth; (2) When selective cutting intensity =1 (clear cutting), y=0. Might as well assume the selective cutting carrying on because of the selective cutting intensity causes age-class y which the linearity drops:

$$y = \text{int}(L \times (1 - \beta) + 0.5) \quad (4)$$

Where: L is age-class before selective cutting, β is the selective cutting intensity.

Stand age linear decreasing caused by selective cutting is shown in table 1.

5. Matrix generations of remained characters of harvest regulation

Clear cutting harvest regulation in formula (4) is in the specified age class optimally by period, its age classes transferring has only two possibilities: harvesting, stand area is all moving to age class 1; no harvesting, stand area is all moving to age class L+1. In one period, all age classes area transfer completely one time, clear cutting harvest in the reservation matrix A (A is the digital matrix) is such form and as a binding matrix of linear programming.

Selective cutting harvest regulation in formula (4) is also in the specified age class optimally by period, its age classes transferring has only three possibilities: (1) Selective cutting, stand area by selective cutting is all moving to age class K; (2) Stand area without selective cutting is all moving to age class L+1; (3) No selective cutting, stand area is all moving to age class L+1 within one period. All age classes area transfer completely twice, the original reservation matrix A (A is the digital matrix) is unable to complete a binding matrix of linear programming.

It is necessary to construct a character-“reserved matrix” which recorded composition of preserve area. As for how to form reserved matrix, finally a new planning model, it is done by the program.

Table 1. Stand age linear decreasing caused by selective cutting

Age class	selective cutting intensity .1	.2	.3	.4	.5	.6	.7	.8	.9	1.0(clear cutting)
1	1	1	1	1	1	0	0	0	0	1
2	2	2	1	1	1	1	1	0	0	0
3	3	2	2	2	2	1	1	1	0	0
4	4	3	3	2	2	2	1	1	0	0
5	5	4	4	3	3	2	2	1	1	0
6	5	5	4	4	3	2	2	1	1	0
7	6	6	5	4	4	3	2	1	1	0
8	7	6	6	5	4	3	2	2	1	0

It should be noted:

1. The formula meets these two boundary conditions;
2. Table 8-7 data changes in accordance with L and L is the input parameters. For example, L=8, selective cutting intensity = 0, 1, age classes 8 decreasing to 7, age classes 7 to 6,..., age classes 2 to 2, age classes1 to 1, it changes with selective cutting intensity. When selective cutting intensity = 1, age classes all decrease to 0;
3. Due to regeneration must keep pace with harvesting, so only when clear cutting decreases to age class 0, it is modified to age classes 1.

6. Forest harvest regulation of selective cutting

(1) Model of harvest regulation with selective cutting

Model of harvest regulation with selective cutting is shown in Table 2.

Table 2. Model of harvest regulation with selective cutting

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8
Present age class area	467	361	167	178	10	3	3	20
Goal age class area	0	51	100	131	171	202	251	303
Volume per hectare	20	25	55	70	75	80	90	100

Adjust periods= 6
Age boundary of nocutting= 0
selective cutting intensity =.3
Goal area limit: allowable error between adjust end area and goal area ≤ 10%。

（2）Decision variable of harvest regulation with selective cutting

Decision variable of harvest regulation with selective cutting is shown in table 3.

Table 3. Decision variable of harvest regulation with selective cutting

Under selective cutting intensity	=0.3dropping age class caused by selective cutting	Period 1	period 2	period 3	period 4	period 5	period 6
1	1	X1	X9	X17	X25	X33	X41
2	1	X2	X10	X18	X26	X34	X42
3	2	X3	X11	X19	X27	X35	X43
4	3	X4	X12	X20	X28	X36	X44
5	4	X5	X13	X21	X29	X37	X45
6	4	X6	X14	X22	X30	X38	X46
7	5	X7	X15	X23	X31	X39	X47
8	6	X8	X16	X24	X32	X40	X48

（3）Matrix of restrain condition reserved by selective cutting

Matrix of restrain condition reserved by selective cutting is shown in（5）。

Reserved Restrain ofRestrain of Restrain of Restrain of Restrain of Restrain of Goal
area period 1 period 2 period 3 period 4 period 5 period 6
a1 +X1+X2 +X9+X10 +X17+X18+X25+X26+X33+X34 +X41+X42 b1
a2 a1-X1+X3 +X1+X2-X9+X11 +X9+X10-X17+X19 +X17+X18-X25+X27 +X25+X26-X33+X35
+X33+X34-X41+X43 b2
a3 a2-X2+X4 a1-X1+X3-X10+X12 +X1+X2-X9+X11-X18+X20 +X9+X10-X17+X19-X26+X28
+X17+X18-X25+X27-X34+X36 +X25+X26-X33+X35-X42+X44 b3
a4 a3-X3+X5+X6 a2-X2+X4-X11+X13+X14 a1-X1+X3-X10+X12-X19+X21+X22
+X1+X2-X9+X11-X18+X20-X27+X29+X30 +X9+X10-X17+X19-X26+X28-X35+X37+X38
+X17+X18-X25+X27-X34+X36-X43+X45+X46 b4
a5 a4-X4+X7 a3-X3+X5+X6-X12+X15 a2-X2+X4-X11+X13+X14-X20+X23
a1-X1+X3-X10+X12-X19+X21+X22-X28+X31 +X1+X2-X9+X11-X18+X20-X27+X29+X30-X36+X39
+X9+X10-X17+X19-X26+X28-X35+X37+X38-X44+X47b5 （5）
a6 a5-X5+X8 a4-X4+X7-X13+X16 a3-X3+X5+X6-X12+X15-X21+X24
a2-X2+X4-X11+X13+X14-X20+X23-X29+X32 a1-X1+X3-X10+X12-X19+X21+X22-X28+X31-X37+X40
+X1+X2-X9+X11-X18+X20-X27+X29+X30-X36+X39-X45+X48 b6
a7 a6-X6 a5-X5+X8-X14 a4-X4+X7-X13+X16-X22 a3-X3+X5+X6-X12+X15-X21+X24-X30
a2-X2+X4-X11+X13+X14-X20+X23-X29+X32-X38
a1-X1+X3-X10+X12-X19+X21+X22-X28+X31-X37+X40-X46 b7
a8 a7-X7+a8-X8 a6-X6-X15+a7-X7+a8-X8-X16 a5-X5-X14-X23+a6-X6-X15+a7-X7+a8-X16-X24
a4-X4-X13-X22-X31+a5-X5-X14-X23+a6-X6-X15+a7+a8-X24-X32
a3-X3-X12-X21-X30-X39+a4-X4-X13-X22-X31+a5-X14-X23+a6+a7+a8-X32-X40
a2-X2+X4-X11-X20-X29-X38-X47+a3-X3-X12-X21-X30-X39+a4-X4-X22-X31+a5+a6+a7+a8-X40-X48 b8
Goal function value= 31514

（4）Optimal cutting area of different periods

Optimal cutting area of different periods is shown in table 4。

Table 4. Optimal cutting area of different periods

Age class	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	56.1
4	0	0	0	0	56.1	110.0
5	10.0	181	57.0	289.3	298.1	144.1
6	0	0	0	0	0	0
7	3.0	0	0	0	0	0
8	20.0	0	3.0	20.0	0	123.0
Total cutting	33	181	60	309.3	354.2	433.2

Total cutting area of all periods= 1370。

（5）Cutting volume of different periods

Cutting volume of different periods is shown in table 5。

Table 5. Cutting volume of different periods

Age class	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6
1	0	0	0	0	0 0	
2	0	0	0	0	0 0	
3	0	0	0	0	0 926	
4	0	0	0	0	1178 2310	
5	225	4073	1283	6509	6707 3242	
6	0	0	0	0	0 0	
7	81	0	0	0	0 0	
8	600	0	90	600	0 3690	
Total cutting	906	4073	1373	7109	7885 10168	

Total cutting volume of all periods= 31512。

（6）Remaining area at end of different periods

Remaining area at end of different periods is shown in table 6。

Table 6. Remaining area at end of different periods

Age class	Period 0	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6(goal)
1	467.0	0	0	0	0	0	0
2	361.0	467.0	0	0	0	0	56.1
3	167.0	361.0	467.0	0	0	56.1	110.0
4	178.0	177.0	542.0	524.0	289.3	298.1	144.1
5	10.0	181.0	177.0	542.0	524.0	233.2	188.1
6	3.0	20.0	0	123.0	272.7	225.9	212.1
7	3.0	3.0	20.0	0	123.0	272.7	225.9
8	20.0	0	3.0	20.0	0	123.0	272.7
Total	1209.0	1209.0	1209.0	1209.0	1209.0	1209.0	1209.0

（7）Remaining volume at end of different periods

Remaining volume at end of different periods is shown in table 7。

Table 7. Remaining volume at end of different periods

Age class	Period 0	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6
1	9340	0	0	0	0	0	0
2	9025	11675	0	0	0	0	1403
3	9185	19855	25685	0	0	3086	6050
4	12460	12390	37940	36680	20251	20867	10087
5	750	13575	13275	40650	39300	17490	14108
6	240	1600	0	9840	21816	18072	16968
7	270	270	1800	0	11070	24543	20331
8	2000	0	300	2000	0	12300	27270
Total Volume	43270	59365	79000	89170	92437	96358	96216

7 Summary

1. The forest harvest regulation with selective cutting and forest harvest regulation with clear cutting are one kind of forestry optimization model, they integrate forest regulation's important decision-making question in the linear programming model optimization of decision-making track.

2. The characteristic of selective cuttings causing “1 age-grade easily flawing” is mainly caused by the selective cutting age-grade decreasing function, and drops scoping is related with selective cutting intensity and selective cutting age class. Only 2 age class with selective cuttings possibly has 1 age- class. Using 4 sheds and 5 entering function in the decreasing function, is because the age class dropping process is so.

3. Under the solution condition in the same level parameter, the selective cutting comparing to clearing cutting, the solution has following differences: (1) The selective cutting area has the rise, but the selective cutting volume (goal function) drops greatly: (2) The reserved volume of selective cutting rises; (3) The fluctuation of optimal solution also drops; (4) Destructive to forest ecology drops; (5) The system has the good expansion function.

4. Consideration of selective cutting harvest regulation in production feasible design is: (1) The equality constraint is smaller, it relaxes cutting control; (2) The greatest age class area transfer in return type, it reduces cutting; (3) The selective cutting causes age class dropping to have conservative slightly, it is in the absorption condition.

Reference

1. Zhao Lili, Li Changsheng. Harvest regulation based on sustainable management of forest resource [J]. World Rural Observations, 2011, 3(1):92-96.
2. Gong P. Determining the Optimal Planting Density and Land Expectation Value-A Numerical Evaluation of Decision Model[J]. Forest Science, 1998, 44(3):356-364.
3. Haight R, Monserud R. Optimizing any-aged management of mixed-species stands：II. Effects of decision criteria[J]. Forest Science, 1990, 36(1):125-144.
4. Haight R. Optimal management of loblolly pine plantations with stochastic price trends[J]. Canadian Journal of Forest Research (Print), 1993, 23(1):41-48.
5. Hyytiainen K, Tahvonen O, Valsta L. Optimum Juvenile Density, Harvesting, and Stand Structure in Even-Aged Scots Pine Stands[J]. Forest Science, 2005, 51(2):120-133.

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