

**Path Analysis of Harvest Regulation with Selective Cutting**

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**Abstract:** The forest harvest regulation with selective cutting is one kind of forestry optimization model. Firstly, decision variable and matrix of restrain condition were established. Secondly, Cutting area and remaining area were calculated for Taizhishan Forest Farm Administration Bureau in Hubei Province. Finely, selective cutting path were analysed for 6 periods.

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**Key words:** Path analysis; Harvest regulation; Selective rutting

**1 Decision variable and matrix of restrain condition** selective cutting Decision variable of harvest adjust with  
**1.1 Decision variable of harvest adjust with** selective cutting is shown in table 1.

Table 1 Decision variable of harvest adjust with selective cutting

Under selective cutting intensity =0.3 dropping 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

**1.2 Matrix of restrain condition reserved by selective cutting**  
 Matrix of restrain condition reserved by selective cutting is shown in table 2.

Table 2 Matrix of restrain condition reserved by selective cutting

Reserved area	Restrain of eriod 1	Restrain of period 2	Restrain of period 3	Restrain of period 4	Restrain of period 5	Restrain of period 5	Goal area
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+X47	b5
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-X7+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

**2 Cutting area and remaining area** Optimal cutting area of different periods is shown in table 3.  
**2.1 Optimal cutting area of different periods**

Table 3 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.

## 2.2 Remaining area at end of different periods

Remaining area at end of different periods is

shown in table 4.

Table 4 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

## 3 Path analyses

### 3.1 Selective cutting path at period 1

Selective cutting path at period 1 is shown in table 5.  $a_5$  is completely selective cutting,  $X_5=10$ , therefore  $X_5$  drops completely to age class 4;  $a_7$  is

completely selective cutting,  $X_7=3$ , therefore  $X_7$  drops completely to age class 5;  $a_8$  is completely selective cutting,  $X_8=20$ , therefore  $X_8$  drops completely to age class 6; Attention: The total area is invariable.

Table 5 Selective cutting path of first period

Age class	Remaining area at period 0	Decision variable 1	Restrain condition	Area at period 1
1	$a_1=467$	$X_1$	$+X_1+X_2$	0
2	$a_2=361$	$X_2$	$a_1-X_1+X_3$	467.0
3	$a_3=167$	$X_3$	$a_2-X_2+X_4$	361.0
4	$a_4=178$	$X_4$	$a_3-X_3+X_5+X_6$	$167+10=177.0$
5	$a_5=10$	$X_5=10$	$a_4-X_4+X_7$	$178+3=181.0$
6	$a_6=3$	$X_6$	$a_5-X_5+X_8$	$10-10+20=20.0$
7	$a_7=3$	$X_7=3$	$a_6-X_6$	3.0
8	$a_8=20$	$X_8=20$	$a_7-X_7+a_8-X_8$	$3-3+20-20=0$

### 3.2 Selective cutting path at period 2

Selective cutting path at period 2 is shown in table 6. Age class 5 is completely selective cutting,

$X_{13}=181$ , therefore  $X_{13}$  drops completely to age class 4.

Table 6 Selective cutting route of second period

Age class	Remaining area at period 1	Decision variable 2	Accumulated restrain condition	Area at period 2
1	0	$X_9$	$+X_9+X_{10}$	0
2	467.0	$X_{10}$	$+X_1+X_2-X_9+X_{11}$	0
3	361.0	$X_{11}$	$a_1-X_1+X_3-X_{10}+X_{12}$	467.0
4	177.0	$X_{12}$	$a_2-X_2+X_4-X_{11}+X_{13}+X_{14}$	$361+181=542.0$
5	181.0	$X_{13}=181$	$a_3-X_3+X_5+X_6-X_{12}+X_{15}$	177.0
6	20.0	$X_{14}$	$a_4-X_4+X_7-X_{13}+X_{16}$	0
7	3.0	$X_{15}$	$a_5-X_5+X_8-X_{14}$	20.0
8	0	$X_{16}$	$a_6-X_6-X_{15}+a_7-X_7+a_8-X_8-X_{16}$	3.0

**3.3 Selective cutting path at period 3**

Selective cutting path at period 3 is shown in table 7. Age class 5 is partly selective cutting,  $X_{21}=57$ , therefore  $X_{21}$  drops completely to age class

4, (177-57) increases to age class 6; Age class 8 is completely selective cutting,  $X_{24}=3$ , therefore  $X_{24}$  drops completely to age class 6.

Table 7 Selective cutting path of third period

Age class	Remaining area at period 2	Decision variable 3	Accumulated restrain condition	Area at period 3
1	0	X17	+X17+X18	0
2	0	X18	+X9+X10-X17+X19	0
3	467.0	X19	+X1+X2-X9+X11-X18+X20	0
4	542.0	X20	a1-X1+X3-X10+X12-X19+X21+X22	467+57=524.0
5	177.0	<b>X<sub>21</sub>=57</b>	a2-X2+X4-X11+X13+X14-X20+X23	542.0
6	0	X22	a3-X3+X5+X6-X12+X15-X21+X24	(177-57)+3=123.0
7	20.0	X23	a4-X4+X7-X13+X16-X22	0
8	3.0	<b>X<sub>24</sub>=3</b>	a5-X5-X14-X23+a6-X6-X15+a7-X7+a8-X16-X24	20.0

**3.4 Selective cutting path at period 4**

Selective cutting path at period 4 is shown in table 8. Age class 5 is partly selective cutting,  $X_{29}=289.3$ , therefore  $X_{29}$  drops completely to age

class 4, (542-289.3=252.7) increases to age class 6; Age class 8 is completely selective cutting,  $X_{32}=20$ , therefore  $X_{32}$  drops completely to age class 6.

Table 8 Selective cutting path of fourth period

Age class	Remaining area at period 3	Decision variable 4	Accumulated restrain condition (omit)	Area at period 4
1	0	X25		0
2	0	X26		0
3	0	X27		0
4	524.0	X28		289.3=289.3
5	542.0	<b>X<sub>29</sub>=289.3</b>		524.0
6	123.0	X30		542-289.3+20=272.7
7	0	X31		123.0
8	20.0	<b>X<sub>32</sub>=20</b>		0

**3.5 Selective cutting path at period 5**

Selective cutting path at period 5 is shown in table 9. Age class 4 is partly selective cutting,  $X_{56.1}=289.3$ , therefore  $X_{36}$  drops completely to age

class 3, (289.3-56.1=233.2) increases to age class 5; Age class 5 is partly selective cutting,  $X_{37}=298.1$ , therefore  $X_{37}$  drops to age class 4, (524-298.1=225.9) increases to age class 6.

Table 9 Selective cutting path of fifth period

Age class	Remaining area at period 4	Decision variable 5	Accumulated restrain condition (omit)	Area at period 5
1	0	X33		0
2	0	X34		0
3	0	X35		0+56.1=56.1
4	289.3	<b>X<sub>36</sub>=56.1</b>		298.1
5	524.0	<b>X<sub>37</sub>=298.1</b>		0+233.2=233.2
6	272.7	X38		0+225.9=225.9
7	123.0	X39		272.7
8	0	X40		123.0

**3.6 Selective cutting path at period 6**

Selective cutting path at period 6 is shown in table 10. Age class 3 is completely selective cutting;

Age class 4 is partly selective cutting; Age class 5 is partly selective cutting; Age class 8 is completely selective cutting.

Table 10 Selective cutting path of sixth period

Age class	Remaining area at period 5	Decision variable 6	Accumulated restrain condition ( omit)	Area at period 6
1	0	X41		0
2	0	X42		0+56.1=56.1
3	56.1	<b>X43=56.1</b>		0+110=110.0
4	298.1	<b>X44=110</b>		0+144.1=144.1
5	233.2	<b>X45=144.1</b>		298-110=188.1
6	225.9	X46		(233.2-144.1)+123=212.1
7	272.7	X47		225.9
8	123.0	<b>X48=123</b>		272.7

By above analysis of 6 periods, it has completely promulgated path of Harvest Regulation with Selective Cutting. It has proven the accuracy and completeness of optimized method accuracy and completeness.

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