



# 4C user manual

## Management in 4C: description of method and control

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## 1 ADAPTIVE MANAGEMENT (FLAG\_MG=2)

This management type was developed for special analyses in Brandenburg (Germany).

### 1.1 Thinning

Thinning is controlled by height-growth intervals (younger stands) and by time intervals (older stands). The measures are selected according to instructions for Brandenburg.

#### 1.1.1 Tending of plantations (dominant height at 3 m)

- Withdrawal of 30% for spruce and Douglas fir, at half withdrawal of the strongest trees and at the other half evenly distributed over all trees
- Withdrawal of 30% for beech, oak and Scots pine, at half withdrawal of the strongest trees and at the other half evenly distributed over all trees

#### 1.1.2 Brushing (dominant height at 9 m)

optional as:

a) moderate Thinning from below

- Withdrawal the trees of the retired stand with WEIBULL-function and parameter  $k_B = 1,8$  (WENK/ GEROLD) until 1/10 of basal area is reached/ withdrawn

b) heavy Thinning from below

- Withdrawal the trees of the retired stand with WEIBULL-function and parameter  $k_B = 1,6(?)$  (WENK/ GEROLD) until 1/10 of basal area is reached/ withdrawn

c) (low) Thinning from above

- Withdrawal the trees of the retired stand with WEIBULL-function and parameter  $k_B = 1,2$  (WENK/ GEROLD) until 1/10 of basal area is reached/ withdrawn

d) Selection-Thinning

- Withdrawal normally distributed from the strongest third of all trees, the double number of the selection trees (alternative: withdrawal with adjusted WEIBULL-function over the strongest third of all trees)

#### 1.1.3 Tending of younger stands (dominant height at 12 m and 15 m)

optional as:

a) moderat Thinning from below

- same procedure as 2.a (brushing)

b) heavy Thinning from below



- same procedure as 2.b (brushing)

c) (low) Thinning from above

- same procedure as 2.c (brushing)

d) Selection-Thinning

- Withdrawal normally distributed from the *strongest* third of all trees, the one and a half number of the selection trees (alternative: withdrawal with adjusted WEIBULL-function over the strongest third of all trees)

### **1.1.4 Tending of stands (dominant height > 15 m)**

Controlled with time intervals from x years

optional as:

a) moderate Thinning from below

- same procedure as 2.a (brushing)

b) (low) Thinning from above

- same procedure as 2.c (brushing)

c) Selection-Thinning

- Withdrawal normally distributed of the second third of the strongest of all trees, same as number of selection trees (alternative withdrawal with WEIBULL-function over the second third of strongest of all trees)

### **1.1.5 Set a system of skidroads**

optionally at one of the thinning phases 1. To 4.

- by distances of skidroads with 25 till 30 m and a width of 4 m: 15% of the number of all trees were withdrawn in equally distribution (proportionately to the withdrawal of trees at 15% of the whole area)

## **1.2 Regeneration**

Age-definitions:

Age U = Rotation period	for Scots pine	=	140 years
(Brandenburg)	for oak	=	160 years (till 240 years)
	for beech	=	150 years
	for spruce	=	110 years
	for birch, elder, poplar	=	80 years



Age X = Age of beginning regeneration (planting, natural regeneration)

(Brandenburg)	for Scots pine	=	110 years
	for oak	=	130 years (bis 240 years)
	for beech	=	110 years
	for spruce	=	80 years
	for birch, elder, poplar	=	60 years

Regeneration of trees in three version, optional as:

a) Clear Cutting

- Ex age U minus 15 years no thinning until reaching age U
- At age U clear cutting and planting of young trees (starting of initialization)

b) Shelterwood-Management

- Starting of regeneration at age X through
  - Withdrawal of 30% of the basal area of the stand from second and least third of the strongest of all trees (with WEIBULL-function or equally distributed), substitute for the regular thinning at this age
  - Initialization of regeneration (Natural regeneration) or man-made (planting of younger trees under older trees)
- To continue the regeneration at age X+15 through
  - Withdrawal of 40% of the basal area of the stand from second and least third of the strongest of all trees (with WEIBULL-function or equally distributed), substitute for the regular thinning at this age
- Taking over of regeneration at age U by
  - Cutting the older trees
  - Taking over (describe new) of the Understore = the regeneration as the main-stand

### 1.3 Remarks

- Nearly all values of thinning parameters can be modified by a management control file which has to specify for a stand
- Modification are possible for:  
thinning intensity, thinning 'height' and thinning period, rotation time



## 1.4 Management control

Description of input data for adaptive management (flag\_mg = 2)

! 1.Row : ho1,ho2,ho3,ho4 (cm): target values for dominant height

! 2.Row: thinning regimes thin\_flag1, thr1,.....thr6, thr7, mgreg

! thin\_flag1 = 0 : tending / = 1: no tending

! thinning types für thr1...thr4:

! 1 – thinning from below low thinning ( moderate)

! 2 - thinning from below (heavy)

! 3 – thinning from

! 4 - selective thinning

! thr5: 0 – no skid roads, 1 – with skid roads

! thr6: hoi – height value for skid roads

! thr7: harvesting regime: 0 - nothing 1 - shelterwood 2 – clear cut

!

mgreg	regeneration	pine %	oak %
0	nothing		
1	natural; controled by species.par		
2			
3	Multi-cohort appr.		
4	planting	20	80
5	planting	30	70
6		50	50
7	planting	70	30
8	planting	90	10
9	Mixed stand, definded in the model (amod_plant)		
10	pine		
11	beech		
12	oak		
13	spruce		
14	birch		
20	planting file		



- ! 3.Row : +- limits for hoi (cm)
- ! 4.Row : thinning period if hdom>ho4
- ! 5.Row : rel. reduction in the case of skidding roads
- ! Row 6-9: order of species: beech, spruce, pine, oak, birch
- ! 6.Row : number of selective trees per species
- ! 7.Row : relative reduction tending of younger stands
- ! 8.Row : optimum basal area thinning hin\_ob (0 -no, 1- yes);  
and reduction factor ( i.e. 0.9,1.,1.1)
- ! 9.Row : rotation length
- ! 10.Row : first shelterwood cut (age)

#### Example

```

300. 900. 1200. 1500. ! hoi [cm]
1 1 1 1 1 1 900. 1 10 ! thinning from below + Shelterwood + pine regeneration
20. ! +- limits [cm]
10 ! [years] thinning interval for Hdom > 1500.
0.2 ! [%] skidding roads reduction
1 0.8 ! opt. Basal area thinning with thinning intensity 0.8
150 200 200 150 0 ! Z-trees
0.15 0.3 0.15 0.15 0. ! [%] tending of plantation (reduction of tree number per species)
140 140 160 160 0 ! age of first shelterwood operation
110 80 120 130 0 ! rotation length

```

Attention: the example is given for 5 species only, row 6-10 has to enlarge to the actual number of species

## 2 TARGET MANAGEMENT (FLAG\_MG=33)

### 2.1 Description

Target management (flag\_mg = 33) is a management system which includes thinning at given time steps of simulation **by a specified relative portion of the stem biomass** of the specified species with a thinning type. This management can be combined with natural regeneration (flag\_reg= 30 in the simulation description file).

The forest stand is partitioned into three layers:

- Regeneration layer (cohort variable underst = 1)
- Understorey layer (underst = 2)



- Overstorey layer (underst = 0)

A tree cohort moves from the regeneration layer to the understorey layer, if the DBH of the cohort is greater than or equal 20% of the minimum DBH of the total overstorey. A tree cohort moves from the understorey to the overstorey, if the DBH of the tree cohort is greater than or equal 70% of the minimum DBH of the total overstorey.

This partitioning of the stand allows management and thinning of stands with natural regeneration.

By management control a value for relative stem biomass removal is given ( $V_{red}$ ). Using this value the total amount of stem biomass to be removed is calculated:

$$B_{rem} = V_{red} * (B_{os} + B_{us}) \text{ (thinning type 1,2,3)}$$

$$B_{rem} = V_{red} * B_{reg} \text{ (thinning type 4)}$$

$B_{us}$  – total stem biomass of the understorey cohorts (underst = 2)

$B_{os}$  – total stem biomass of the overstorey cohorts (underst = 0)

$B_{reg}$  – total stem biomass of regeneration cohorts (underst = 1)

The following thinning options are available:

#### Thinning from above (thinning type 3):

- At first stem biomass is removed from the overstorey, using the thinning from above with a Weibull-distribution ( $kb = 1.2$ )
- If  $B_{rem} > B_{os}$  then the amount  $B_{us} - (B_{rem} - B_{os})$  has to remove from the understorey with the Weibull distribution thinning from above.

#### Thinning from below (thinning type 1,2):

- Starts in the understorey using thinning from below with the Weibull –distribution ( $kb = 1.8, 1.6$ )
- If  $B_{rem} > B_{us}$  then  $B_{os} - (B_{rem} - B_{us})$  has to remove from the overstorey with thinning from below
- If there is no understorey thinning starts in the overstorey

#### Tending (thinning type 4):

- Tending is applied only to the regeneration (underst = 1)
- Trees are equally distributed removed from the regeneration cohorts until  $B_{rem}$  is reached



## 2.2 Management control

### Example for <name>.man

! management control file flag\_mg = 33

0 ! mgreg, default/ regeneration: planting of spruce, 10 – pine, 11 – beech, 12 - oak

0 0 0 0 0 0 0 0 0 0 0 0 ! default

0 0 5000 0 0 0 0 0 0 0 0 ! default/ number of plants beech, spruce, pine, oak

7 ! number of thinning operations

10 0.3 3 1 0 ! simulation year/  $V_{red}$ / species number / thinning type

20 0.3 3 3 0 ! thinning

30 0.3 3 3 0 ! thinning

35 0.9 3 3 0 ! thinning

35 0 0 0 1 ! planting 5000 pines

36 0 3 3 0 ! felling old pines, overstorey

45 0.9 3 3 2 ! thinning planted pines, understorey

### Important:

If  $V_{red}$  is greater than 1 then it indicates the target biomass of the thinning measure.





### 3 TARGET MANAGEMENT (TARGET\_THINNING\_OC, FLAG\_MG=3)

Target management (flag\_mg = 3) is a management system which includes thinning at given time steps of simulation described by a **target number of stems** of the specified species and a thinning type. This management can be combined with planting in the management control file.

The forest stand is partitioned into three layers:

- Regeneration/planting layer (underst = 4)
- Understorey layer (underst = 2)
- Overstorey layer (underst = 0)

Planted saplings are signed as planting layer are shifted to the understorey if the height of the saplings is greater or equal 1.3 m. There is no shift from understorey to overstorey, because it is not clear before simulating when (in which year) the understorey will be overstorey and therefore difficult to manage. If a new classification into under- and overstorey is required the model run should be finished and the outputfile <name>\_tree.ini1 can be used for the next simulation. At the beginning of the simulation the stand is classified into under-and overstorey.

By management control (data file <name>.man) a value for the target stem number is given. Using this value the total amount of stems to be removed is calculated:

#### 3.1 Thinning

The following thinning options are available for the overstorey and the understorey:

a) Thinning from above (thinning type 3)

- Withdrawal the trees of the retired stand with WEIBULL-function and parameter  $kB = 1,2$  (WENK/ GEROLD) until the target value is reached

b) Thinning from below ():

- heavy thinning from below (thinning type 2):  
Withdrawal the trees of the retired stand with WEIBULL-function and parameter  $kB = 1.5$  WENK/ GEROLD) the target value is reached
- moderate thinning from below(thinning type 1):  
Withdrawal the trees of the retired stand with WEIBULL-function and parameter  $kB = 1.8$  (WENK/ GEROLD) until the target value is reached

#### 3.2 Planting

Planting is controlled by the following parameters:

a) mreg – defines which species type is planted (row 1)



- 10 - pine
- 11 – beech
- 12 – oak
- 13 - spruce

b) Number of saplings per ha in row 3 for all considered tree species in 4C (at the moment 10).

New types of planting like mixed stands (pine/oak) has to define if necessary (e.g. mixed planting of oak and pine).

**Attention/ important note:**

- If planting is used in the management control file, please, do not use soil vegetation in the simulation control file (flag\_sveg = 0).

### 3.3 Management control

**Example for <name>.man**

! management control file flag\_mg = 3

Row 1: 12   ! mgreg ( oak):

Row 2 0 0 0 0 0 0 0 0 0 0 0 0           ! rotation period (not used)

Row 3: 0 0 0 3000 0 0 0 0 0 0 0 0 0 ! number of plants (3000 oak saplings/ha)

Row 4: 5   ! number of measures

**Comment** The following rows describe the management activities

1. value: year
2. value: target value of stem number
3. value: species type (same number as in species.par)
4. value: thinning method (1,2,3)
- 5.value: thinning from the overstorey (0) or understorey (2)

If planting is used then value 2-4 are zero and the fifth value is 1, that means oak is planted with 3000 saplings/ha (example)

Row 5: 1 136 4 2 2           ! thinning oak target value 136 stems

Row 6: 1 0 3 3 0           ! felling pine

Row 7: 6 100 4 3 0       ! thinning oak, target value 100

Row 8: 26 0 0 0 1       ! planting oak





Row 9: 31 0 4 3 0 ! felling old oak

**Important note:**

- If the target values of stem number are greater than 0 and less than 1, the value indicates a relative value of the remaining stand. That means, if the target value indicate 0.9 then 90 % of the stem number remains after thinning.
- Do not fell a stand and plant a new one in the same year due to output problems in the veg-files. The best method is to remove 90 percent and planting in one year and in a following year to remove the remaining old trees.