



# **FORRISK**

# **Final Conference**

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Manual for future crisis and risk management - Main  
outcomes

Forest management and Silviculture  
(Eduard Hochbichler, BOKU; Radek Pokorný, MENDELU)



# **Output T.1.2. – Manual for future crisis and risk management in forestry**

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Universität für Bodenkultur Wien (LP)	Peter Baier Elisabeth Gerhardt Eduard Hochbichler Markus Immitzer Thomas Kirisits Sigrid Netherer Zoran Trailovic
Mendelova univerzita v Brně (PP 2)	Petr Čermák Petr Martinek Jitka Meňházová Radek Pokorný Dalibor Šafařík Alena Šamonilová Tomáš Žid
Bundesanstalt für Agrarwirtschaft und Bergbauernfragen (PP 3)	Thomas Resl Gerhard Gahleitner Karin Heinschink



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Table 1: Current presence of main stand types across the three main altitudinal vegetation zones (c = colline, sm = submontane, m = montane) in the Czech Republic (CZ) and Austria (AT)

Stand types/altitude level	CZ c < 350 m	CZ sm 350 - 650 m	CZ m > 650 m	AT c < 300 m	AT sm 300 - 500 m	AT m > 500 m
Secondary pure spruce stands	rare	middle	high	middle	high	high
Scots pine stands	high	middle	low	middle	low	
Mixed oak stands	high	low		low	low	
Oak - noble hardwood stands	low	low				
Mixed noble hardwood stands	low	low				
Red oak stands				low	low	
European beech stand	rare	high	low	rare	low	low
Beech - noble hardwood stands						
beech - fir stands					rare	
Mixed pioneer tree species	rare	low	middle	rare	rare	rare
Mixed Scots pine-oak stands	low	rare		low	low	
Mixed spruce hardwood stands	low	middle	low	rare		
spruce -beech stand						
larch-beech stands					rare	
Mixed European beech, larch, fir	rare	high	low			
Spruce fir beech stands		low	middle		low	middle
spruce- fir stands					low	low
spruce -alder - fir stand				low	low	
Scots pine - spruce stand					middle	low
spruce -larch stand					low	
Natural spruce dominated stands			middle			middle
Mixed Douglas fir - oak stands	rare	rare		rare	rare	rare
Mixed Douglas fir - beech stands				rare	rare	rare



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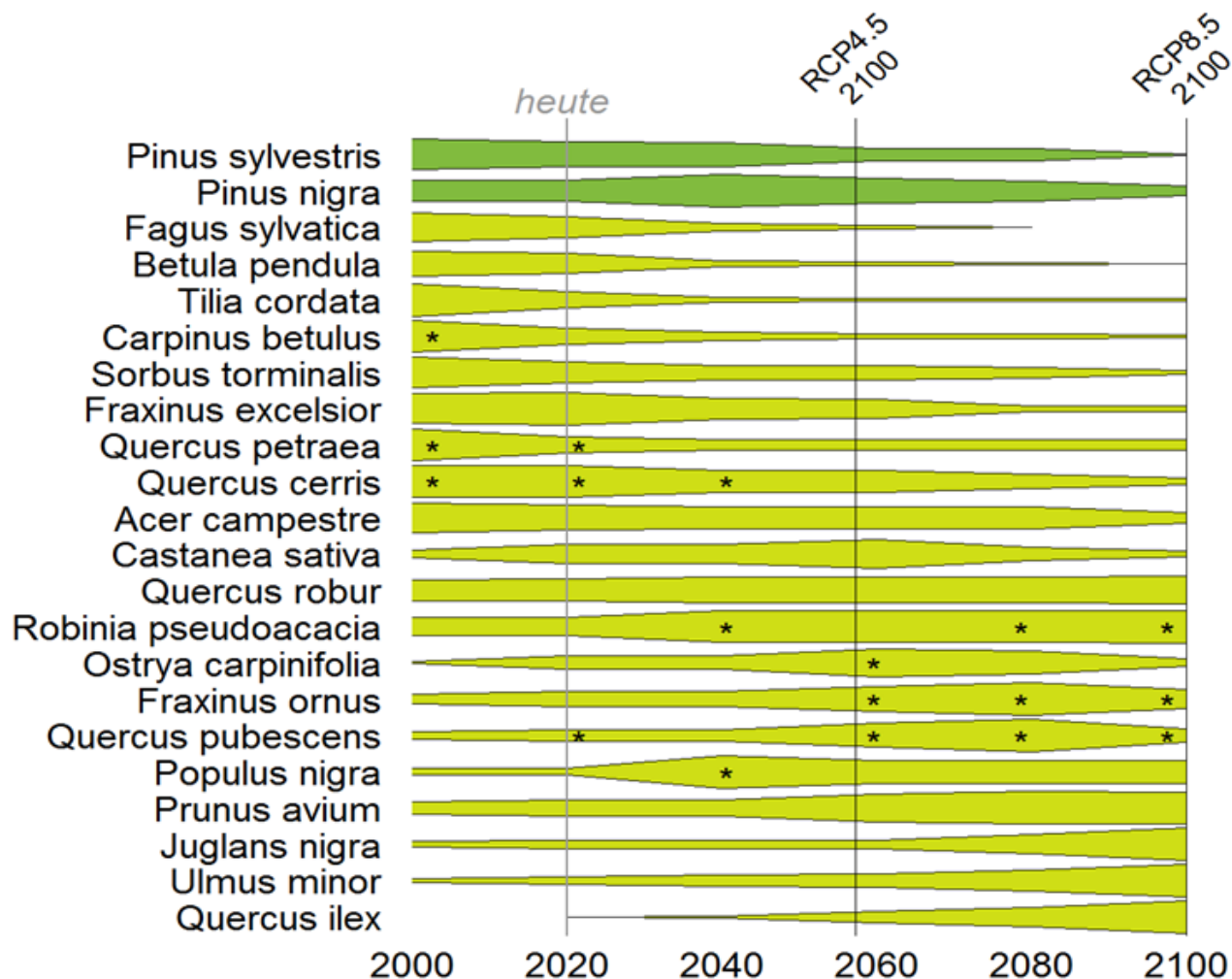


Figure 1: Tree species suitability for 2100 according to two different scenarios rcp4.5 and rcp8.5 for South Moravia region (CZ; source: T. Mette et al. LWF, 2021, see ASFORCLIC project).





CZ	AT	nutrient/site typ	water regime	Quro	Qupe	Quce	Qupu	Quil	Cabe	Fasy	Acps	Acpl	Frex	Soto	Sodo	Prav	Algl	Alin	Tisp	Qure	Be.sp	Po.sp.	Soau	Pley	Plab	Lade	Abal	Pame
c < 300 m	c < 350 m		dry																									
		nutrient-rich	moderate fresh-fresh																									
sm 300-500 m	sm 300-650 m	nutrient-poor	dry																									
		gley	fresh, wet																									
		nutrient-rich	moderate fresh-fresh																									
		nutrient-poor	moderate dry-dry																									
m > 500 m	m > 650 m	nutrient-poor	moderate fresh-fresh																									
		gley	fresh, wet																									
		nutrient-moderate	moderate fresh-fresh																									
		gley	gley																									
Flood plain																												

Table 9: Tree species suitability and nutrient/sites type and water regime and altitudinal vegetation zones (c = colline, sm = submontane, m = montane)



Management goal/types [MGT]/ Include level/ tree species share [%]	CZ_AT colline	CZ_AT submontane	CZ_AT montane	birch sp.	oak sp.	black alder	noble sp.	other deciduous sp.	poplar sp.	beech	red oak	Scots pine	spruce	fir	larch	Douglas fir
Mixed oak stands					70-90			10-30								
Oak - noble hardwood stands					20-60	20-60		10-30								
Mixed noble hardwood stands							70-90	10-30								
Red oak stands								10-30			70-90					
Beech stand										>90						
Beech - noble hardwood stands							40-60			40-60						
Beech - fir stands										50-70				30-50		
Mixed pioneer tree species				>90					>90							
Mixed Scots pine - oak stands					10-40						60-90					
Mixed spruce hardwood stands																
Spruce - beech stand										40-80			20-60			
Larch - beech stands										30-40					60-70	
Beech - larch - fir stand										20-40				20-40	20-60	
Spruce fir beech stands										20-40				20-40		
Spruce - fir stands													50-70	30-50		
Spruce - alder - fir stand						20-50							20-50	20-50		
Scots pine - spruce stand								10-20				30-50	30-50			
Spruce - larch stand													50-70		30-50	
Natural spruce dominated stands													>90			
Douglas fir - oak stands					20-40											60-80
Douglas fir - beech stands										20-40						60-80

Table 10: Tree species composition and tree species shares (%) for the defined MGTs (Management goal types)



Oak sp.	100%	4,400 – 5,000	2*1.1 m	2,000 – 2,500	3*1.3 m; 4*0.9 m	Cluster planting: 80 cluster with 25 plants per cluster [2000 n/ha]
Oak sp.		9,000*	1*1.1 m			
Maple sp., ash	100%	3,500 – 4,200	2*1.2/1.4 m	1,100 – 1,600	3*3 m; 6*1.5 m	
Maple sp., Alnus gl.	100%	4,000*	2*1.25 m			
Ash, Lime, Hornbeam, Elm, other oaks	100%	6,000*	1*1.6 m			
Wild service tree, wild fruit tree sp.	100%	3,500 – 4,200	2*1.2/1.4 m	2,000 – 2,500	3*1.3 m; 4*0.9 m	
Walnut, blacknut	100%	----- 2,000 – 2,500	---- 2*2 m	600 – 800 600 – 800	6*2.5 m; 4*3 m	
Wild cherry	100%	-----	----	600 – 800	6*2.5 m; 4*3 m	
Wild cherry, Aspen, Birch, Rowan, Willow, Walnut	100%	3,000*	2*1,6 m			
Birch	100%	-----	----	1,100 – 1,600	3*3 m	
Black alder	100%	-----	----	1,100 – 1,600	4*2 m; 3*3 m	
Red oak	100%	2,500 – 3,500	2*2 m; 2*1.4 m	1,100 – 1,600	3*3 m; 3*2,5 m	other broadleaved tree species (natural regeneration)
Beech	100%	8,000 – 10,000	1*1.3 m	----	---	
	100%	9,000 <sup>1</sup>	1*1.1 m			
Scots pine	100%	8,000 – 10,000	1*1.3 m	---		
Scots pine	100%	8,000 <sup>1</sup>	1*1.25 m			
White pine	100%	5,000 <sup>1</sup>	2*1m			
Dwarf pine	100%	2,500 <sup>1</sup>	2*2 m			
Austrian pine + other pines	100%	7,000 <sup>1</sup>	1*1,4 m			
Larch	100%	1,600 - 2,000	2*2.5 m	---		
Larch, Douglas fir, Grand fir	100%	2,500 <sup>1</sup>	2*2 m			
Spruce, fir	100%	2,000 - 2,500	2*2 m	---		
Spruce	100%	3,000 <sup>1</sup>	2*1.6 m			

<sup>1</sup>Relevant minimum numbers  
for the Czech Republic  
respecting Act. No. 456/2021



Tree species	Target stem diameter (cm)	Crown cover percentage (%) (main stand)	Crown width (m)	Number of future crop trees (n/ha)
Oak sp., maple sp., wild cherry, ash, elm	<b>60+</b>	<b>80</b>	<b>12 (10-14)</b>	<b>70 (60-80)</b>
Beech	<b>60+</b>	<b>90</b>	<b>10 (8-12)</b>	<b>90 (80-100)</b>
Wild service tree	<b>50</b>	<b>80</b>	<b>10 (9-11)</b>	<b>90 (80-100)</b>
Birch, Black alder	<b>40</b>	<b>80</b>	<b>9 (8-10)</b>	<b>140 (130-150)</b>
Scots pine	<b>45+</b>	<b>90</b>	<b>7 (6-8)</b>	<b>200 (180-220)</b>
Larch	<b>60+</b>	<b>90</b>	<b>9 (8-10)</b>	<b>120 (10-140)</b>
Fir	<b>60+</b>	<b>90</b>	<b>8 (6-10)</b>	<b>300 (150-350)</b>
Spruce	<b>45+</b>	<b>90</b>	<b>6 (5-7)</b>	<b>300 (120-250)</b>
Douglas fir	<b>50+</b>	<b>90</b>	<b>7 (6-8)</b>	<b>200 (180-220)</b>

Table 12: Relation of target diameter and crown width and average number of future crop trees in relation to target diameter and crown cover percentage of main stand

## •Regeneration:

mostly natural regeneration in groups after target tree felling, in forest gaps up to ca 0.1 ha respecting regenerated tree species ecological demands; long time period or rather continuous regeneration period; missing target and valuable tree species could be added artificially (e.g. spruce, pine, larch, oak, fir, cherry, service tree etc.)

## •Tending: no full-area (per groups), two-phases →

1. phase (up to thicket stage): leave it to spontaneous development (except of co-ordination of stand tree species composition), automatic initialization of tree height increment, development of more-less final length of clear stem ca 10 – 12 m and co-ordination of tree species composition,

2. phase (*pole stage - timber*) – target tree method approach = initialization of stem thickness increment by systematic release cuts surrounding target C-trees (varying in time with the stand development, e.g. from ca 100 – 150 to later on 30 – 60 of C-trees, Table 12)

## •Cutting of target trees – *timber/mature stage*:

- full-area irregular selection of trees from the point of view of – health, quality, yield respecting stand and site conditions, from individual to group selection approach up to 0.1 or 0.2 ha, cutting criteria:

- health status

- mechanical stability (especially during transformation, reflecting slenderness ratio and crown size and position, see Table 12)

- quality (of stem and crown)

- yield – target dimensions (around 50-60 cm in dbh, see Table 12)

- occurrence and development of natural regeneration (valid mostly for spruce and sun-loving tree species)

- intensity of cutting – respecting concrete site conditions and stand demands, preliminary follow the value of total current increment (in m<sup>3</sup>/ha/year), usually 1 or 2



Management goal types [MGT]/altitude leve/ silvicultural system	CZ - c 350	CZ - sm 650	CZ - m> 650	CZ_AS	CCF	AT - c 300	AT - sm 500	AT - m> 750	AT_AS	AT_CCF
conversion/transition Secondary pure spruce stands				x					x	
conversion/transition secondary pure Scots pine stands				x	x				x	
Mixed oak stands				x	x CWS				x	x CWS
Oak - noble hardwood stonds				x					x	x CWS
Mixed noble hardwood stands									x	
Red oak stands									x	
Beech stand				x	x				x	x
Beech - noble hardwood stands									x	
Beech - fir Stands					x				x	x
Mixed pioneer tree species				x	x				x	
Mixed Scots pine -oak stands					x				x	x
Mixed spruce hardwood stands				x	x				x	
Spruce -beech stand					x				x	x
Larch-beech stands					x				x	
Beech - larch - fir stand				x	x				x	
Spruce fir beech stands				x	x				x	x
Spruce- fir stands					x				x	x
Spruce -alder - fir stand									x	
Scots pine - spruce stand					x				x	x
Spruce -larch stand									x	
Natural spruce dominated stands					x				x	x
Douglas fir - oak stands				x	x				x	
Douglas f ir - beech stands									x	



## Secondary pure spruce stands

### A) RISK ASSESSMENT

RISK FACTOR/STAND DEVELOPMENT	REGENERATION/ YOUNG STANDS			THICKET			POLE STAGE			TIMBER			TIMBER/ MATURE			DAUERWALD PERMANENT TREE COVER		
	C	S	M	C	S	M	C	S	M	C	S	M	C	S	M	C	S	M
Storm	0	0	0	0	0	0	2	2	2	3	3	3	3	3	3	–	1	1
Snow/ice/rime	1	1	1	2	3	2	2	3	2	2	3	2	2	3	2	–	1	1
Drought	3	2	1	3	2	1	3	3	1	3	3	1	3	3	1	–	1	1
Fire	3	2	2	3	2	2	3	2	2	2	1	1	2	1	1	–	3	2
Bark beetles	0	0	0	1	1	1	2	2	1	3	3	2	3	3	3	–	2	1
Game	3	3	3	3	3	3	2	2	2	0	0	0	0	0	0	–	1	1

*Vegetation zone: C – colline, S – submontane, M – mountane*

SCALE: 0 – no risk... 3 – extreme high risk; – absent (see context with the previous table with current presence of stand tapes in CZ)





## Secondary pure spruce stands

2 thicket	2.1 snow/ice/rime	<ul style="list-style-type: none"><li>• work with stand density – suitable crown length</li><li>• processing of damaged wood (risk of bark beetle outbreak)</li><li>• frequent control of the stands</li></ul>
	2.2 drought (and subsequent bark beetle calamity)	<ul style="list-style-type: none"><li>• search for trees secondarily infested by bark beetles</li><li>• bark beetle monitoring (pheromone traps, trapping trees)</li><li>• timely sanitation (larval/pupal stage)</li><li>• optimization of stand density (maintaining a favourable stand climate)</li></ul>
	2.3 fire	--> see above 1.2
	2.4 bark beetles ( <i>P. chalcographus</i> )	<b>Prevention and control</b> <ul style="list-style-type: none"><li>• search for trees infested by bark beetles, processing of damaged wood, bark beetle monitoring (pheromone traps)</li></ul> <b>Defense</b> <ul style="list-style-type: none"><li>• removal of mining residues (branches, peaks), use traps (upper part, weaker trees, trapping stacks) and pheromone traps</li></ul>
	2.5 game	--> see above 1.3





## Secondary pure spruce stands

Silvicultural system	Age class system
Vegetation zone	colline – submontane
Target of growing stock	Conversion and/or transformation <ul style="list-style-type: none"> <li>• colline: mixed deciduous and/or mixed oak stands</li> <li>• submontane and montane: deciduous and coniferous mixed stands</li> </ul>
Production goal	Timber of high quality (saw timber); target diameter: spruce 45 cm
Rotation period	60 - 80 (100) y;

Growth classes		Initial state – measures/action
	young stands height	weeding and/or cleaning; promoting of mixed tree species; integrating of pioneer tree species spruce: normal density negative selection; stem number reduction in dense stands mixture regulations
	thicket	promoting of mixed tree species; integrating of pioneer tree species spruce: normal density negative selection; stem number reduction in dense stands mixture regulations
	pole stage	spruce: positive thinning (future crop tree thinning) maintaining of mixed tree species and promoting mixed tree species of good quality maintain and promote nurse shade tolerant species; <b>treatment of previously managed stands:</b> combination of light thinning from above and selective thinning; maintenance and support of mixed tree species
	timber dbh 20 – 50 cm	spruce: further positive thinning activities (future crop tree thinning) - release target trees; maintenance and support of mixed tree species <b>treatment of previously managed stands:</b> combination of light thinning from above and selective thinning; maintenance and support of mixed tree species; with dbh > 30 cm transition to stock maintenance
	timber/mature regeneration	<b>Transformation:</b> tree species change by clear cut and reforestation; <b>Conversion:</b> combination of natural and artificial regeneration; shelterwood cut and group- selection cut [target tree diameter harvesting] <b>colline: transformation to mixed deciduous stands</b> Reforestation: normal spacing: spruce (2*2 m; 2,500 n/ha), oak (2*1 m; 5,000 n/ha), maple (2*1.3 m-; 4,000 n/ha), cherry (wide spacing: cherry (4*3m; 700 n/ha) <b>submontane: transformation to mixed spruce hardwood stands</b> Reforestation: normal spacing: spruce (2*2 m; 2,500 n/ha), oak (2*1 m; 5,000 n/ha), maple (2*1.3 m-; 4,000 n/ha), cherry (wide spacing: cherry (4*3 m; 700 n/ha) - single mixed stands: wild cherry (service trees) + hornbeam, linden, beech. - support mixture species for oak stands (nurse shade tolerate species as linden, hornbeam, beech or field maple) - sycamore or Norway maple can be managed in group or as monoculture; - in case of group mixture avoid monoculture larger than approx. 0.1(2) ha; - avoid gap in regeneration





## Mixed spruce hardwood stands

### A) RISK ASSESSMENT

RISK FACTOR/STAND DEVELOPMENT	REGENERATION/ YOUNG STANDS			THICKET			POLE STAGE			TIMBER			TIMBER/ MATURE			DAUERWALD PERMANENT TREE COVER		
	C	S	M	C	S	M	C	S	M	C	S	M	C	S	M	C	S	M
Storm	0	0	0	0	0	0	1	1	1	2	2	2	2	2	2	–	–	1
Snow/ice/rime	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	–	–	1
Drought	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	–	–	1
Fire	3	2	2	2	1	1	2	1	1	2	1	1	2	1	1	–	–	2
Bark beetles	0	0	0	0	0	0	1	1	1	2	1	1	2	2	2	–	–	1
Game	3	3	3	3	3	3	2	2	2	0	0	0	1	1	1	–	–	1



## Mixed spruce hardwood stands

2 thicket	2.1 snow/ice/rime	<ul style="list-style-type: none"><li>• work with stand density – suitable crown length</li><li>• processing of damaged wood (risk of bark beetle outbreak)</li><li>• frequent control of the stands</li></ul>
	2.2 drought (and subsequent bark beetle calamity)	<ul style="list-style-type: none"><li>• search for trees secondarily infested by bark beetles or defoliators</li><li>• bark beetle monitoring (pheromone traps, trapping trees)</li><li>• timely sanitation (larval/pupal stage)</li></ul>
	2.3 fire	--> see above 1.2
	2.4 game	--> see above 1.3



## Mixed spruce hardwood stands

Management type	Mixed spruce hardwood stands
Silvicultural system	Age class system
Vegetation zone	Submontane
Target of growing stock	50/(40 – 60)% spruce (larch, fir) 50 (40 - 60)% deciduous (beech, Norway maple)
Production goal	Timber of high quality (saw timber); target diameter: spruce, fir 45+ cm, larch 60+ cm; deciduous tree species 60+ cm
Rotation period	Spruce, fir: 80 – 120y; larch 80 - 120 y; beech and Norway maple 80 - 120 y



Growth classes	initial state - measures/action
Regeneration	<p>Reforestation:</p> <p>normal spacing: spruce/fir (2*2 m; 2,500 n/ha), larch (2*2.5 m; 2,000 n/ha); beech (1*1.3 m; 8,000 n/ha)</p> <ul style="list-style-type: none"> <li>- single mixed stands: wild cherry (service trees) + hornbeam, linden, beech.</li> <li>- support mixture species for oak stands (nurse shade tolerate species as linden, hornbeam, beech or field maple)</li> <li>- sycamore or Norway maple can be managed in group or as monoculture;</li> <li>- in case of group mixture avoid monoculture larger than approx. 0.1(2) ha;</li> <li>- avoid gap in regeneration</li> </ul>
young stands	<p>weeding and/or cleaning: negative selection;</p> <p>artificial pruning: pruning of stands with lower densities (oak below 5,000 n/ha; maple below approx. 3,000 n/ha; pruning for wild cherry)</p>
Thicket	<p>normal density: negative clearing – remove wolf trees</p> <ul style="list-style-type: none"> <li>- mixture control</li> <li>- keep full canopy</li> </ul>
pole stage	<p>normal density</p> <ul style="list-style-type: none"> <li>- positive thinning;</li> <li>- support nurse shade tolerant species;</li> </ul>
timber	<ul style="list-style-type: none"> <li>- release target tress;</li> </ul>
timber/mature	<ul style="list-style-type: none"> <li>- preparation felling – release target tress, remove undesirable trees, support for natural regeneration; combination of natural and artificial regeneration; strip and/or group- selection cutting or in combination</li> <li>target diameter harvesting</li> </ul>



Management type	<b>Mixed spruce hardwood stands</b>
Silvicultural system	CFF – depends on MGT (light demanding vs. shade tolerant tree species)
Vegetation zone	montane
Target of growing stock	50/(40 – 60)% spruce (larch, fir) 50 (40 -60)% deciduous (beech, Norway maple)
Production goal	<b>Timber of high quality (saw timber); target diameter: spruce, fir 45+ cm, larch 60+ cm; deciduous tree species 60+ cm</b>
<b>Growth classes</b>	<b>initial state - measures/action</b>
Pole stage/timber (20 – 40 cm)	use maximum self-thinning process; girdling, support quality trees, remove wolf trees; <b>structural thinning</b>
timber/mature stand	<b>target diameter harvesting</b> <ul style="list-style-type: none"> <li>• support for natural regeneration;</li> <li>• species composition can be modified</li> </ul>