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Methodological Guide

Project 101074426 – LIFE21-CCA-CZ-LIFE Adapt Brdy

Climate Change Adaptation of Forests in the Brdy Highland

Version	Date	Author/Organization
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CONTENT

Photo on the front page: Diverse structure of the forest.

1. INTRODUCTION

The manual provides management concepts that describe the silvicultural measures for individual types of forest development and stand types with the aim of their conversion into the desired target state. The target states are forest stands that are diverse in species, age and spatial distribution and that are more resilient to climate variations and negative impacts of biotic and abiotic agents.

Adaptation of forest ecosystems to climate change is in line with the key state and ministerial documents:

- National Forest Programme II.
- Concept of State Forestry Policy until 2035
- Strategy of VLS ČR, s.p. for the period 2021-2025.

2. ACRONYMS

CDS	target species composition
CHS / TMG	target management group
CHS	target management unit
DO	demonstration plot
FMP	forest management plan
HZ	silvicultural system (P – shelterwood, N – strip felling, H – clearcutting, V – selection cut)
LHC / FMPA	forest management plan area
PCHS / TMSG	target management sub-group
PT / ST	stand type
PT	stand type
RSH	general management guidelines
TVL / FDT	forest development type

Tree species:

Czech	English*	Scientific name
BB – javor babyka	FM – field maple	*Acer campestre* L.
BK – buk lesní	BE – European beech	*Fagus sylvatica* L.
BO – borovice lesní	SP – Scots pine	*Pinus sylvestris* L.
BR – bříza bělokorá	SBI – silver birch	*Betula pendula* Roth
BRP – bříza pýřitá	BI – downy birch	*Betula pubescens* Ehrh.
DB – duby letní a zimní	OK – pedunculate + sessile oaks	*Quercus robur* L. + *Q. petraea* (Matt.) Liebl.
DG – douglaska tisolistá	DF – Douglas fir	*Pseudotsuga menziesii* (Mirb.) Franco
HB – habr obecný	HBM – hornbeam	*Carpinus betulus* L.
JD – jedle bělokorá	SF – silver fir	*Abies alba* Mill.
JDO – jedle obrovská	GF – grand fir	*Abies grandis* (Doug. ex D. Don) Lindl.
JL – jilmy	EM – elms	*Ulmus* sp.
JLH – jilm horský	WEM – wych elm	*Ulmus glabra* Hudson
JR – jeřáb ptačí	ROW – rowan	*Sorbus aucuparia* L.
JS – jasan ztepilý	AH – ash	*Fraxinus excelsior* L.
JV – javor mléč	NOM – Norway maple	*Acer platanoides* L.
KL – javor klen	SY – sycamore maple	*Acer pseudoplatanus* L.
LP – lípa srdčitá	SLI – small-leaved linden	*Tilia cordata* Mill.
MD – modřín opadavý	EL – European larch	*Larix decidua* Mill.
OL – olše lepkavá	CAR – common alder	*Alnus glutinosa* (L.) Gaertner
OLS – olše šedá	GAR – grey alder	*Alnus incana* (L.) Moench
OS – topol osika	ASP – aspen	*Populus tremula* L.
SM – smrk ztepilý	NS – Norway spruce	*Picea abies* (L.) Karst.

**borrowed from Jenkins et al. 2011. Tree Species – A document listing the tree species included in the 2011 Production Forecast.*

3. EXPLANATION OF TERMS

Forest Development types (FDT) are determined taking into account the diversity of forest stands given the soil and vegetation conditions and the existing typological planning;

1. acid and nutrient-medium beech forests with oak (TMG 43 and 45)
2. nutrient-medium and acid fir forests with oak (TMG 47)
3. acid, poor, and stony fir forests and spruce-beech forests (TMG 51 and 53)
4. acid, poor, nutrient-medium beech and spruce-fir forests, wet fir forests, wet poor fir-spruce + maple-ash (TMG 57, 59, 79, and 29).

Stand type (ST) the current state of the forest with respect to the time "distance" from the target state; three basic types are distinguished – distant, transitional and target; the definition of each ST is given in Table No. xx in Chapter 6

Operational block a group of units of the spatial arrangement of the forest, typically of sub-compartments of compartments, which are divided by a network of skidding lines. The harvest intervention is carried out at the same time.

4. GAME HUNTING AS A PREREQUISITE FOR SUCCESSFUL FOREST CONVERSION

The main objective is to reduce the population of cloven-hoofed game to optimum levels that correspond and do not cause disturbances to the natural environment. Optimum game populations will provide the conditions for the development of natural regeneration of all habitat-suitable tree species while the need to protect them from game damage will be significantly reduced.

Optimum game populations are defined as those that do not hinder the establishment and growth of naturally regenerating, habitat-suitable tree species and provide conditions for possible artificial regeneration without the need for protection against game damage.

4.1. Assessment of game populations

An environmentally and economically sustainable game population density is achieved if:

1. the main tree species typical for the given site are regenerated with no protective measures adopted,
2. the vegetation does not differ substantially from the phytosociology of the site and its diversity is ensured.

The sustainable density of red deer is 0.5–1 animal per 100 ha (already at a density below 1.5 per 100 ha, fir trees naturally regenerate with no need for fencing).

Before the sustainable game population density of 0.5–1 deer per 100 ha is reached, it will be necessary to plan hunting so that the number of animals harvested exceeds the annual growth rate and the desired sustainable game population density is achieved in the shortest time possible. Once this is met, the level of the game harvest schedule will be at the level of the increment.

4.2.Game management and hunting as a tool in silviculture

4.2.1. Hunting facilities

Hunting facilities are numbered, registered both graphically and alphanumerically. The inspection of the condition of hunting facilities is the responsibility of the respective forest worker. The forest worker's responsibilities are mainly to keep an ongoing graphic record of the functional facilities, to check their condition, to provide for the necessary repairs and to ensure the disposal of non-functional facilities that can no longer be repaired. All the hunting facilities shall be inspected minimum once a year in the period before 30 April. Non-functional facilities shall be made inaccessible in the period before 31 May. The inspection shall be recorded in the Register of Hunting Facilities. It is forbidden to lock any hunting facilities. Before any purchase of new facilities or their construction by contractors, the head of the forest district shall consult this with the hunting operations staff and the person responsible for purchasing goods and services.

4.2.2. Targeted group hunt

With the number of game declining towards optimum levels sustainable for a balanced ecosystem, individual hunting of game will become more demanding. Individual hunting will more often be replaced by group hunting with standby (chase and stalk). This should become more efficient in terms of meeting the hunting plan.

4.2.3. Individual hunt

The professional clearance and selective hunting is considered to be the hunting of antlerless cloven-hoofed game (hinds and calves), and trophy cloven-hoofed game up to 2 years of age within the statutory time limit. The selective hunting of red deer of the 1st age class (1–4 years) up to 130 points with antlers up to an 8-point is without restriction for employees and they are paid the same fee as for antlerless red deer (hinds and calves).

All game taken will be recorded in the Game Management Register and in the Record of Game Harvest. Each forest district shall keep the Record of Game Harvest. Any mortalities found shall also be listed in the Record of Game Harvest. All harvest shall be recorded on weekly basis by 10 a.m. each Monday at the latest. Recorded mortalities will be documented with photographs and a report. The game harvest reports for the preceding month will be submitted regularly to the hunting operations staff always by the 15th day of the following month.

The trophies of roe deer yearling knobbers, roe deer yearling bucks with an average beam height of 10 cm or less, bucks up to the 8-point on antlers, fallow deer spike bucks, and sika deer spike bucks are not required to be submitted for assessment and trophy show. If the listed trophies are not presented, they shall be submitted to the head forest warden for inspection after hunting (in the hind). Other trophies shall always be properly scored and the scoring tables generated in the Game Management Register programme.

The employees are motivated to hunt hinds and calves by all available means (harvest of hinds and calves is one of the evaluated criteria when awarding bonuses).

If the staff capacity of a forest district is not sufficient for the specified harvest, the staff from the forest districts where the specified harvest is fulfilled will be deployed.

Hunting shall be primarily directed to places where excessive damage to stands by game is apparent and to places where, with regard to the nature of the stand, game damage must be prevented (stands with underplanting, stands with emerging natural regeneration).

4.2.4. Hunting schedule for the hunting ground

The hunting schedule is issued annually by a decision of the Division Director and shall be structured according to hunting grounds and forest districts. The annex to this decision includes a schedule of the implementation of the hunting plan for individual forest districts and months. It shall be supervised by the division directorate and shall form part of the quarterly evaluation of the heads of the forest districts. The Head of the Forest District is responsible for the implementation of the respective overall hunting plan. The hunting schedule shall be compiled in a way to achieve/maintain a sustainable density of red deer of 0.5–1 animal per 100 ha.

The optimum game density for a given site is assessed in control plots (hereafter "CPs"). Simple comparison of the state of vegetation in the fenced and unfenced area. It is necessary to

continue reducing the game population until the target tree species show similar growth in both plots.

Control plots are established specifically in places where the impacts of game on stands need to be monitored most.

4.2.5. Game Management

The game populations must reflect the given environment and its carrying capacity. The quality of the habitat is crucial for maintaining game populations in the forests in the long term. Appropriate transformation of forest stands will create a high quality and stable habitat for game in the medium and long term.

On this basis, the number of feeding facilities will be reduced during the transition period. When optimum game numbers are reached, these feeding facilities will be completely removed. The list of game feeding facilities is continuously maintained by the forest districts and submitted as an annex to the Game Management Plan to the operations staff as at 31 March. Feeding facilities may only be used for bulk feed. By 30 April, all such facilities including their immediate surroundings must be cleaned and disinfected. This cleaning shall be carried out at least once a year. By the same date, all facilities used for the care of game must be inspected by the forest district staff. A record shall be made of the inspection and the proposed measures such as repair, disposal, etc., in the list of facilities, which is drawn up by the heads of the forest districts as an annex to the annual game management plan. The maintenance and removal of feeding facilities is the responsibility of the head of the forest district.

Figure 1 Hunting stand

Figure 2 Damage by bark stripping

Figure 3 Damage by browsing

Figure 4 Differences in vegetation between fenced and unfenced parts of the forest plantation

Figure 5 European rowan (Sorbus aucuparia) is the main indicator of the game populations in the hunting ground

5. FOREST MANAGEMENT

5.1. Basis principles

The basic principle of regeneration felling is work in operational blocks that are accessible through a network of skidding lines. The working procedure for the division of stands into corridors is described in Chapter 3.2.1. The area of the operational blocks on which regeneration felling is carried out in a given year is determined by the volume of such felling, which should correspond to the current increment.

Based on the research within the project QF4132 carried out with the support of the National Agency for Agricultural Research (NAZV) entitled **Optimization of Work Procedures Focused on Forest Dynamics Indicators for the Needs of Repeated Cycles of the Forest Inventory of the Czech Republic** (Černý, M. et al., 2007), the current increment was calculated at **9.6 m³/ha/year**. The calculation was made on the basis of a survey between 1996 and 2005.

With an average size of a forests section 1,128 ha, the average annual cut potential per forest section is up to 10,800 m³. Given that the harvesting in the amount of the decennial increment is carried out within a decennium in two operations (1 x every five years), the annual harvest is done on an area of about 20% of the determined forest section, i.e. about 225 ha.

5.2. Logging operations

5.2.1. Methodology for establishing boundary and maintenance corridors

Secondary access to stands is a prerequisite for harmless and economical deployment of a harvester-forwarder units in logging and forwarding. With regard to the technical capabilities of the machinery, it is necessary to route the skidding lines along the gradient of the slopes. The gradient that the machine can safely handle (in good weather) is 35 %. The transverse connecting lines shall not have a transverse gradient of more than 10 %. Otherwise, the vehicle may tip over.

Establishing boundary and maintenance corridors through secondary access line network

The operational (logging) blocks should ideally be determined within the individual sub-compartments and fully interconnected within the compartment. Within the operational block (in drivable terrain), the secondary lines have the same direction and pass through all stand groups (irrespective of their age).

The lines in the stand are of a permanent nature – tractors and forwarders extracting harvested timber are not allowed to leave these lines or enter the stand freely. The direction of the lines should respect the gradient and the carrying capacity of the terrain. The lines also have a reinforcing function in the stands. They should therefore be mainly perpendicular to the direction of the prevailing winds (in flat terrain and where the primary skidding network allows it).

The lines should be 4 m wide in a straight course at regular intervals of 30 m (from centre to centre of the lines). The length of the lines within the primary road network should not exceed 350 m. In the case of longer routes, it is necessary to incorporate a reinforced skidding line.

In the space between two lines, an auxiliary unmarked line can be routed through the centre, which is only wide enough for the width of the particular machine – mainly used in young stands up to 60 years of age.

When establishing new stands, the lines should already be taken into account. When reforesting, no planting is carried out in the area of the line with a minimum width of 3 metres.

When carrying out juvenile thinning in young stands with a continuous area exceeding 2 ha (including several smaller contiguous stand groups totalling more than 2 ha), we divide the area with 4 m wide lines at regular intervals of 30 m (from the centre to the centre of the lines) within the juvenile thinning process (these lines perform a reinforcing function in the stands).

When necessary, forwarders, harvesters and other forestry machinery with a specific axle load of up to 6 tonnes may move outside the marked lines, provided that their dimensions allow for safe passage through the stand causing no damage.

Work procedure

Prior to commencing any work (handover of the site) within the operational block, a graphical layout of the boundary and maintenance corridors will be drawn up in the FMP module IS Seiwin 5. This applies to stands being newly established, thinned or felled.

On the basis of the graphical layout, the individual lines will be marked in the field. In the case of a location change in the terrain, the graphical layout will be adjusted accordingly. The lines need not be physically marked in the field if the harvester operator is able to identify the lines on the basis of the digital graphical layout provided.

Such prepared site will be handed over in writing and the handover report will include a graphical layout. The proposed technological procedure and regulations must be observed and supervised during the course of the work.

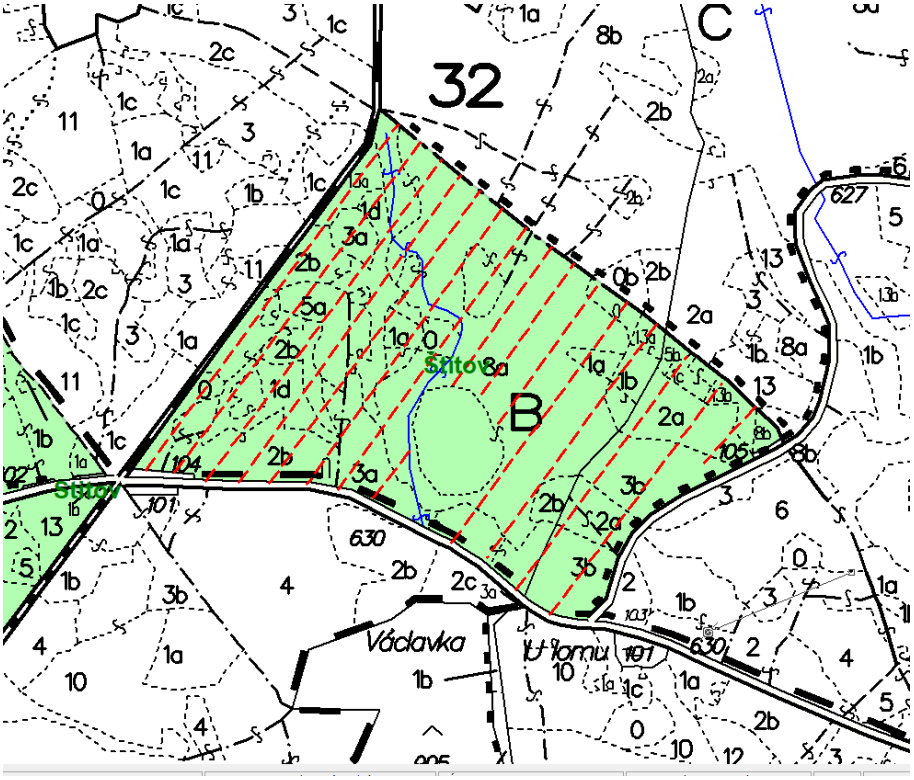

Figure 6 Map layout of working plots

Figure 7 Division of working plots by lines

5.2.2. Proposed potential of the total annual cut

With regard to the current increment determined by the inventory (9,6 m³/ha/year) and the area of the forest land in the five management plan areas (FMPA) of the Hořovice Division in the Brdy area (22,737 ha), the total annual cut may reach up to 218,000 m³.

Table 1 Overview of potential total cut by forest FMP areas.

Name of FMPA	Timber land (ha)	Potential annual cut
Jince	4,434	42,000
Obecnice	4,125	40,000
Nepomuk *	4,707	45,000
Mirošov	4,724	45,000
Strašice	4,563	44,000
Total	22,553	216,000

** At FMPA Nepomuk, the actual total annual cut may be proportionately lower, taking into account the high volume of salvage cutting in 2020-2022 and thus the reduced current increment.*

5.2.3. Basic criteria for tending and regeneration felling

Regeneration felling

- regeneration interventions are mostly carried out by selection and shelterwood cutting; in justified cases, small-scale clear-cuts for regeneration may also be used (in the case of advance regeneration of shade trees, e.g. white fir)
- regeneration interventions are carried out twice per decade in the harvest block, always at the rate of half of the decennial increment; in general, the decennial increment in the Brdy area can be determined at 96 m³/ha
- species, age and height diversity is promoted within regeneration interventions
- in selection and shelterwood cutting, the intensity of interventions may be differentiated in the stand
- individuals that have reached their target DBH are primarily removed from the parent stand; the target DBH for spruce in the Brdy area may be considered as 40-50 cm, depending on the site
- regeneration mainly in ST "distant" may be initiated as early as at the age of 60 years
- in old-growth stands (i.e. stands exceeding the regeneration period), the parent stand can be harvested in one or two logging operations to reduce more rapidly the growing stock in these old-growth stands

Figure 8 Selection cutting in the mature forest stand

Improvement felling – stands up to 40 years of age

- promoting species, age and spatial diversity
- promoting individual stability and preservation of long crowns
- uneven intensity of interventions over the stand area, especially in larger groups

Figure 9 Thinning of conifers in a stand up to 40 years old

Figure 10 Thinning of broadleaves in a stand up to 40 years old

Improvement felling – stands over 40 years of age

- maintain a looser canopy by level release of target trees from 1-2 competitors
- support uneven canopy (alternating thinner and denser parts)
- gradual removal of spruce reaching target DBH
- support of admixed trees at the canopy layer and below
- initiation of regeneration of other species (fir, beech)

Figure 11 Thinning in a stand over 40 years old

5.3. Silvicultural measures

5.3.1. Current, natural and target tree species composition in Nature Forest Area 7 – Brdská vrchovina

The basic framework for the structure of forest regeneration is given by the Regional Plan of Forest Development (RPFD) for Nature Forest Area (NFA) 7 – Brdská vrchovina by means of comparing the current, natural and target tree species composition.

The current species composition expresses the share of tree species and their groups in stands. It is derived from the valid data of the comprehensive forest management plans at the time of the update of the RPFD.

The natural species composition is a reconstructed tree species composition of natural forest communities that would presumably exist in the given natural conditions if the forest ecosystems were not affected by man. The natural tree species compositions used most were those reconstructed by K. Plíva and E. Průša. Forest typology experts have updated these and added mainly admixed and interspersed tree species.

The target species composition represents the recommended share of tree species at harvest age that is optimal to ensure the production and non-production functions of the forests. The target species composition is determined in the framework planning for the management groups; or stand types of these management groups in the given NFA. In the detailed planning for the renewal of forest management plans and guidelines, it is applied to specific stands of the forest property. It is designed taking into account the natural conditions for optimal performance of production and non-production functions of the forest while ensuring its sustainable management.

Table 2 Tree species share in current, potential natural and target tree species composition.

Tree species	Current share	Potential natural share	Share in the target tree species composition
Norway spruce	67	7	24
Silver fir	1	30	12
Grand fir	0	0	2
Scots pine	11	3	9
European larch	7	0	11
Douglas fir	0	0	2
Conifers total	**86**	**40**	**60**
Oak	4	17	14
Beech	4	35	18
Birch	2	3	1
Alder	2	1	1
Maple, elm and ash	1	1	3
Linden	0	1	2
Other broadleaves	1	2	1
Broadleaves total	**14**	**60**	**40**
Total	**100**	**100**	**100**

5.3.2. Framework proposal for the structure of overall forest regeneration

The current share of tree species in forest stands, the actual structure of overall forest regeneration (including natural regeneration) by tree species in 2022-2023, the target tree species composition and the proposed share of the structure of overall forest regeneration (including natural regeneration) are given in the following overview.

Table 3 Framework proposal for the structure of overall forest regeneration.

Tree species	Current share of tree species in forest stands according to the RPFD for NFA 7	Real share of tree species in total regeneration in 2022-2023	Target tree species composition according to the RPFD for NFA 7	Framework proposal for the structure of overall forest regeneration
Norway spruce	67	57	24	40
Silver fir	1	3	12	5
Grand fir	0	0	2	0
Scots pine	11	4	9	8
European larch	7	2	11	5
Douglas fir	0	2	2	2
Conifers total	**86**	**68**	**60**	**60**
Oak	4	5	14	10
Beech	4	17	18	20
Birch	2	7	1	5
Alder	2	3	1	1
Maple, elm and ash	1	0	3	1
Linden	0	0	2	2
Other broadleaves	1	0	1	1
Broadleaves total	**14**	**32**	**40**	**40**
Total	**100**	**100**	**100**	**100**

5.3.3. Current and target tree species composition in the territory of forest districts of VLS ČR, s. p. in the area of the Brdy Highland according to the target management groups and sub-groups.

Table 4 Current tree species composition according to FMPA in %.

LHC / FMPA	SM	BO	JD	MD	DB	BK	BR	OL	Other	Total
Jince	58	10	0	16	3	5	3	1	3	100
Obecnice	66	7	1	10	1	4	1	1	9	100
Nepomuk	85	3	1	5	0	3	1	1	1	100
Mirošov	64	6	1	5	3	6	6	3	5	100
Strašice	72	3	1	9	2	5	2	1	4	100

Overview Target species composition according to prevailing TMG:

Acid and nutrient-medium beech-oak forests (TMG 43 and 45)

Stand types 431 and 451

PCHS / TMSG	Target tree species composition
43a	BK 20, DBZ (DB) 25, SM 10, BO 10, JD 10, MD 15, DG 3, LP (KL) 4, JDO 2, BR (OS, JR) 1
43b	BK 35, SM 20, BO 10, JD 10, MD 15, DG 3, LP (KL, DBZ, DB) 4, JDO 2, BR (OS, JR) 1
45b	BK 30, SM 29, JD 10, LP (LPV, KL, JV) 5, MD 15, JL (JLH, JLV, JS, HB, TR, DBZ, DB) 5, DG 2, JDO 3, BR (OS, JR, OLS) 1

Stand type 433

PCHS / TMSG	Target tree species composition
43a	BO 40, DBZ (DB) 20, BK 10, MD 15, DG 3, JD 5, LP (KL) 4, JDO 2, BR (OS, JR, SM) 1
43b	BO 35, BK 25, JD 10, MD 15, DG 3, SM 5, LP (KL, DBZ, DB) 4, JDO 2, BR (OS, JR) 1

Stand type 435

PCHS / TMSG	Target tree species composition
43a	DBZ (DB) 50, BK 15, MD 15, DG 3, JD 5, BO 5, LP (KL) 4, JDO 2, BR (OS, JR, SM) 1
43b	BK 35, MD 15, DBZ (DB) 30, DG 3, BO (JD, SM) 10, LP (KL) 4, JDO 2, BR (OS, JR)

Stand type 436

PCHS / TMSG	Target tree species composition
43a	BK 40, DBZ (DB) 25, MD 15, DG 3, JD 5, BO 5, LP (KL) 4, JDO 2, BR (OS, JR, SM) 1
43b	BK 55, MD 15, DBZ (DB) 10, DG 3, BO (JD, SM) 10, LP (KL) 4, JDO 2, BR (OS, JR) 1

Nutrient-medium and acid fir forests with oak (TMG 47)

Stand type 471

PCHS / TMSG	Target tree species composition
47a	SM 20, JD 15, BK 10, DB (DBZ) 25, MD 10, LP (LPV, JV, KL) 10, JLH (JL, JLV, JS) 5, OL (OLS) 3, JDO 1, BR (OS, JR, HB, BB) 1
47b	DB (DBZ) 30, SM 20, JD 20, BO 10, MD 8, BK (LP) 4, OL (OLS) 5, JDO 2, BR (OS, JR) 1

Stand type 476

PCHS / TMSG	Target tree species composition
47a	DB (DBZ) 18, BK 50, MD 9, LP (LPV, JV, KL, BB, HB, JLH, JL, JLV, JS) 10, JD (SM) 5, OL (OLS) 5, JDO 2, BR (OS, JR, BO) 1
47b	DB (DBZ) 50, JD 19, BK 10, MD 9, SM 5, BO 4, JDO 2, BR (OS, JR, OL, OLS, LP) 1

Acid, poor, and stony fir forests and spruce-beech forests (TMG 51 and 53)

Stand types 511 and 531

PCHS / TMSG	Target tree species composition
51a	SM 40, BK 30, MD 10, JD 10, DG 1, JDO 1, LP (KL, DBZ, DB) 4, BO 3, BR (OS, JR, OLS) 1
51b	SM 50, BK 25, MD 10, JD 5, DG 1, JDO 1, KL 4, BO 3, BR (OS, JR, OLS) 1
53a	SM 40, BK 19, JD 10, MD 15, DG 5, BO 5, LP (KL, DBZ, DB) 5, BR (OS, JR, OLS) 1
53b	SM 46, BK 19, MD 15, JD 10, DG 5, BO 2, KL 2, BR (OS, JR, OLS) 1
53c	SM 46, BK 20, MD 15, JD 10, DG 5, BO 2, BR (OS, JR, OLS) 2

Acid, poor and nutrient-medium beech and spruce fir forests, wet fir forests, wet poor fir-spruce forests + maple ash forests (TMG 57, 59, 79 and 29)

Stand types 571 and 591

PCHS / TMSG	Target tree species composition
57b	SM 45, JD 20, BK 10, MD 6, DG 2, JDO 2, DB 5, LP (LPV, KL, JV, JLH, JS) 9, BR (JR, OS, OL, OLS) 1
57e	SM 40, JD 20, BO 10, BK 15, MD 6, DG 2, JDO 2, BR (JR, OS, OL, OLS) 5
59b	SM 40, JD 25, BK 10, OL (OLS, OS) 10, JS (KL) 10, DB 5

Stand type 597

PCHS / TMSG	Target tree species composition
59b	OL (OLS) 45, SM 20, JD 20, BK 5, JS (KL) 5, DB (OS) 5

Stand type 791

PCHS / TMSG	Target tree species composition
79a	SM 70, BRP (BR, OS, JR) 12, OLS 10, BK 2, JD 5, BO (KL) 1

Stand type 291

PCHS / TMSG	Target tree species composition
29g	JS (DB) 45, KL (JV, BB) 10, OL 10, JD 10, JLV (JL, JLH) 10, BK (LP, HB) 5, BR (OS) 5, SM 5

5.3.4. Basic criteria for regeneration

5.3.4.1. Natural regeneration

Natural regeneration of forest stands on clear-cuts or under storey is a basic pillar of close-to-nature forest management. Preference is given to under storey natural regeneration. Natural regeneration on clear-cuts is preferably applied in the case of clear-cuts caused by natural disasters/infestations.

Naturally regenerated are all the habitat-suitable species of the target tree species composition – Norway spruce, Scots pine, silver fir, European larch, Douglas fir, sessile oak, English oak, European beech, birch, alder, maple, elm or linden.

As from 2027, the area of natural regeneration carried out in the Brdy area will reach a minimum of 200 hectares, i.e. an average of 40 hectares per forest district.

Figure 12 Natural regeneration on the clear-cut area

Figure 13 Natural regeneration under storey

5.3.4.2. Planting

Artificial regeneration by planting is mainly applied for reforestation after salvage cutting in areas where natural regeneration does not occur or is not anticipated, or where natural regeneration is expected only in a part of the clear-cut area.

Artificial regeneration by planting can be carried out in the following ways:

1. In cases of existing natural regeneration – the remaining area of the clear-cut is regenerated artificially by planting **60-100 % of the minimum number of seedlings per hectare**
2. In cases of anticipated natural regeneration – **a reduced number of seedlings per hectare** is planted with greater spacing and a reduced area of clear-cut reforestation
3. In cases where no natural regeneration occurs or is anticipated – **60-100% of the minimum number of seedlings per hectare** are planted

- **Tree species recommended for artificial regeneration by planting:**

Norway spruce (when none of the below mentioned species can be used), Scots pine, silver fir, European larch, Douglas fir, sessile oak, English oak, European beech, European alder, maple, elm, small-leaved linden, wild cherry

- **Recommended minimum area for planting**

is not limited

- **Number of seedlings per hectare (1,000 / ha)**

Table 5 Number of seedlings per hectare (1.000/ha).

Tree species	Minimum 100% *	Minimum 60% **	Reduced ***
Norway spruce	3	1.8	1.5
Scots pine	8	4.8	4
Douglas fir	2.5	1.5	1
English oak	9	5.4	4
Sessile oak	9	5.4	4
European beech	8	4.8	4
European alder	4	2.4	1.5
Maples	4	2.4	1.5
Elms	6	3.6	2
Small-leaved linden	6	3.6	2
Wild cherry	3	1.8	1

* number per ha in accordance with Annex No. 4 of Decree No. 456/2021 Coll.
** number per ha in accordance with Sec. 2(5) of Decree No. 453/2021 Coll.
*** reduced number per ha – a reduced area of reforestation must be reported so that the number of seedlings per ha corresponds to at least 60% of the minimum number per ha (see column *Minimum 60%*)

Figure 14 Artificial regeneration of a clear-cut area with a reduced number of seedlings per ha and the use of natural regeneration

5.3.4.3. Underplanting

Artificial regeneration by underplanting is mainly used to introduce soil improving and stabilizing tree species in forest stands where these cannot be regenerated naturally.

- **Tree species recommended for artificial regeneration by underplanting:**

  Silver fir, European beech

- **Recommended minimum area of underplanting**

Silver fir	0.20 ha
European beech	0.50 ha

- **Number of seedlings per hectare (1,000 / ha)**

  Underplanting does not involve reforestation of clear-cut areas; the minimum number of seedlings per hectare according to Decree No. 456/2021 Coll. is not required.

Table 6 Number of seedlings per hectare (1.000/ha).

Tree species	Nutrient-rich sites *	Other sites **
Silver fir	2	1
European beech	7	3

* sites of edaphic categories S (*oligo-mesotrophica*), B (*mesotrophica*), W (*calcaria*) and H (*illimerosa mesotrophica*), where the production function is preferred

** other sites where the primary functions are other than production, i.e. primarily soil improving and stabilizing

Figure 15 Underplanting European beech

5.3.4.4. Sowing

Artificial regeneration by sowing is mainly used in areas with incomplete explosive ordnance disposal clearance or on sites of extreme ecological series (X, Z, Y), or on other poor sites where regeneration by planting is unsuitable due to the low mineral soil layer.

- **Tree species recommended for artificial regeneration by sowing:**

  Norway spruce, Scots pine, European larch, silver birch, European rowan, and their mixtures

- **Recommended minimum area for sowing**

  is not limited

- **Sowing technology**

strip sowing

Minimum width of a strip	30 cm
Maximum distance of strips	3 m

patch sowing

Minimum size of a patch	30 X 30
Maximum spacing of patches	3 x 3

Figure 16 Patch sowing of tree species mixtures

5.3.4.5. Undersowing

Artificial regeneration by undersowing is mainly used to introduce soil improving and stabilizing tree species in forest stands where these cannot be regenerated naturally.

- **Tree species recommended for artificial regeneration by undersowing:**

  Silver fir

- **Recommended minimum area for undersowing**

  Silver fir 0.20 ha

- **Sowing technology**

strip sowing

Minimum width of a strip	30 cm
Maximum distance of strips	5 m

patch sowing

Minimum size of a patch	50 X 50
Maximum spacing of patches	5 x 5

Figure 17 Undersowing silver fir

5.3.5. Juvenile thinning

Juvenile thinning is an essential tool for modifying the tree species composition and increasing the stability of forest stands.

Basic principles of tending intervention in young forest stands:

- timely intervention
- support for a diverse tree species composition
- reducing the number of individual trees in accordance with the tending model for given tree species
- intervention primarily at the canopy level while retaining the present understorey individuals

Figure 18 Juvenile thinning promoting diverse tree species composition

6. GENERAL MANAGEMENT GUIDELINES (RSH) – a brief summary with basic parameters of forest regeneration and thinning

6.1. Scheme of RSH and relevant stand types (PT) by target management units (CHS)

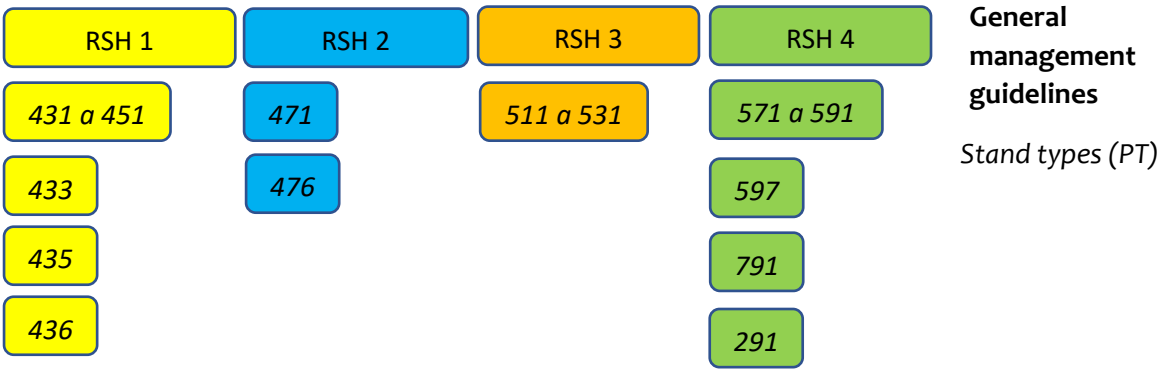

Figure 19 Scheme of RSH and relevant stand types (PT) by target management units (CHS).

6.2. Forest development types

Based on the present status of forest stands in the area of interest, three forest development types were differentiated (target – transitional – distant). Species composition, area of natural regeneration and height structure were main criteria for the mentioned differentiation (see the following table and RSH – project deliverable D2.3 for more details).

Table 7 Stand characteristics for differentiation into forest development types.

	Species composition (% share of NS)	Relative area (%) of natural regeneration	Height structure (number of storeys)
A – target	<50	>50	>2
B – transitional	50 – 75	5 – 50	2
C – distant	>75	<5	1

6.2.1.Sorting according to the scheme and links to sub-chapters

Table 8 Sorting according to the scheme and links to sub-chapters. RSH – General management guideline, HS – management unit, stand type, PT – forest development type (A – target, B – transitional, C – distant), P – stands damaged by biotic and abiotic agents.

RSH	**RSH 1**															
HS	431 and 451				433				435				436			
PT	A	B	C	P	A	B	C	P	A	B	C	P	A	B	C	P
Sub-chapter	I.A	I.B	I.C	I.P	II.A	II.B	II.C	II.P	III.A	III.B	III.C	III.P	IV.A	IV.B	IV.C	IV.P
RSH	**RSH 2**															
HS	471				476											
PT	A	B	C	P	A	B	C	P								
Sub-chapter	I.A	I.B	I.C	I.P	IV.A	IV.B	IV.C	IV.P								
RSH	RSH 3															
HS	511 and 531															
PT	A	B	C	P												
Sub-chapter	I.A	I.B	I.C	I.P												
RSH	RSH 4															
HS	571 and 591				597				791				291			
PT	A	B	C	P	A	B	C	P	A	B	C	P	A	B	C	P
Sub-chapter	I.A	I.B	I.C	I.P	V.A	V.B	V.C	V.P	I.A	I.B	I.C	I.P	I.A	I.B	I.C	I.P

I.A

Stand types "spruce" (431, 451, 471, 511, 531, 571, 591, 791, 291)

Present status (type) **A – target**

Selection felling interventions according to criteria:

- **Sanitation selection –** salvage felling at all growing stages.

- Support of quality and stability – in younger parts positive selection, i.e. **to release quality crop trees including maintenance of accompanying species**, in older parts preferred removal of low-quality competitors.
  - → NS and SF individual selection.
  - → OK, BE, SY, CAR, AH, EM preferable group selection.

- **Support and maintenance** of target stand structure.
  - → Adjustments based on comparison of the current structure with the model.

- **Harvest of "mature" trees** according to their development stage and management goals. The removed trees are not only the thickest dominants but **also those which will not perform well and which hamper the vertical canopy development.**
  - → Target diameter ranges between 40-60 cm.
  - → The possibility of leaving interspersed species OK, BE, SF to decomposition (especially if they are over-strengthened and of poor quality).

- **Intervention intensity** (including salvage cut) in the context of total current increment accumulated following a previous intervention.

- Support of regeneration - **to release locally**, preferentially at sites where a vertical canopy is needed to develop. **Support of light-demanding** species.
  - → NS and SF individually or small patches, BE or SY in small groups.
  - → OK, SP, EL, DF, CAR, GAR, EM, BI, SBI, ASP, ROW.

Figure 20 To support mixed woody species, it is necessary to provide sufficient space for the development of their crowns.

I.B

Stand types "spruce" (431, 451, 471, 511, 531, 571, 591, 791, 291)

Present status (type) **B – transitional**

Regeneration:

- **To prefer natural regeneration**, large shelterwood cutting (or of minor extent or minor shelterwood cuttings ahead) should be done **with uneven intensity**.
- To prefer removal of low-quality trees, **to release canopy** in order to initialise natural regeneration.

→ In total – 2 interventions per 10 yrs (removal amounts ca 5-yr increment of standing volume).

→ In category "O" (nutrient-medium gleyed soils) excessive canopy opening is not desirable due to the risk of subsequent weed development.

- To **combine** a **target-diameter felling** approach (regeneration initiated), group felling (growth and self-pruning) **and thinning** (more uniform structure stands in areas among the above-mentioned shelterwood parts).
- **Artificial regeneration** (including underplanting or undersowing) **only for CDS species, which are missing** (SF and BE).

→ Soil scarification can be done if possible.

→ In the following phases, we should maintain the residual parent stand and **postpone** its presence on the site or alternatively leave it on the site with **no final felling** conducted.

- To initiate **regeneration of SF ahead of time**, BE up to 10 years after regeneration of SF. Open areas from salvage cut can be used for artificial or combined (if they are present in the mother stand) regeneration of light-demanding trees (SP, OK, SY, EL, DF, CAR, GAR, EM, SBI, BI, ASP, AH).

→ On larger areas after salvage cut, leave SBI, ROW, ASP as preparatory trees for subsequent easier introduction of SF or BE.

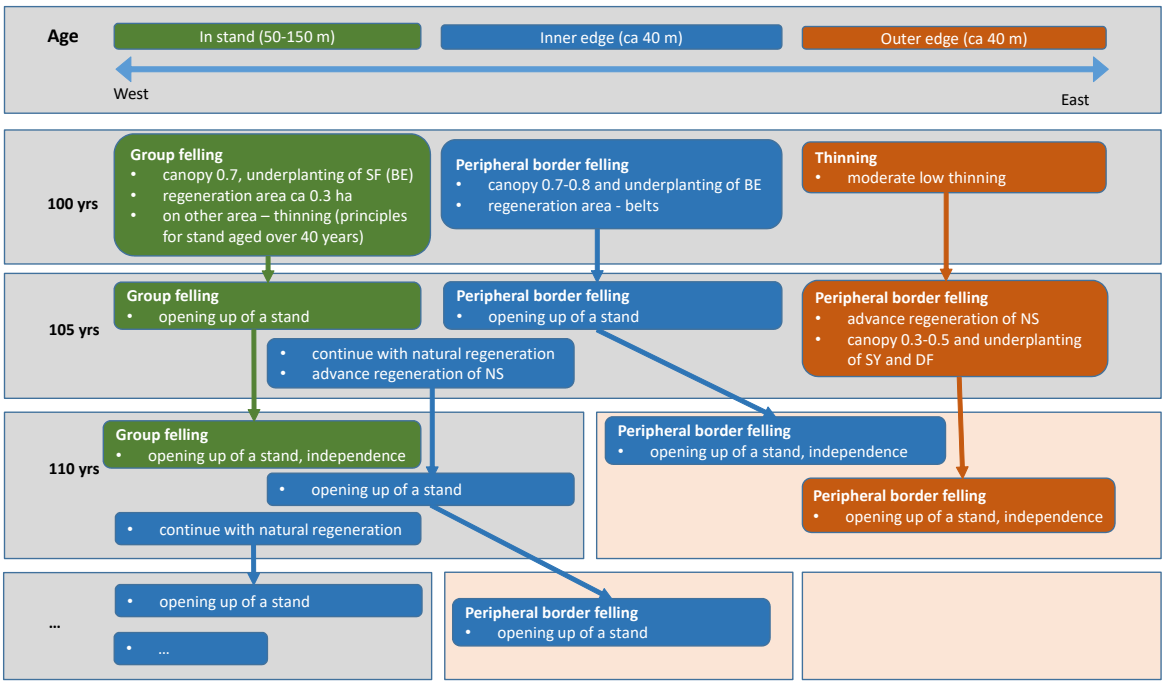

Figure 21 An example of the temporal and spatial sequence of regeneration of NS dominated stands to mixture with BE and SF (modified according to Sachsenforst management principles).

Tending:

Plantations (underplanting, undersowing) and advance growth

- In young stands with gaps (exceeding 0.04 ha), **repair planting with crop species that are capable of stabilizing and soil-improving** (EL, DF, OK, SY, CAR, EM) or support of pioneering species such as ROW, SBI and ASP.

→ **If sheltered** by a parent stand (upper storey), **to release accompanying species** and conduct sanitation cut.

→ **If no shelter** above, advance growth **should be cleaned** (in NS also using a shrub cutter – schematic approach) supporting (even individually) accompanying species.

Stands younger than 40 years

- Heavy thinning in NS focused on individual stability and maintenance of long live crowns (see scheme).
- **In larger groups, uneven thinning intensity** is beneficial (mosaic following site conditions, health and share of valuable species).

→ **To release accompanying species** at the expense of NS.

→ At the same time **establish skidding lines** in appropriate density (4-5 m wide lines 30 m apart).

Stands older than 40 years

- To maintain (preferably locally) **thinner canopy** as crop trees (ca 300 per ha) are released from 1-2 competitors **supporting natural regeneration** (species from CDS) already after thinning.
- To **support accompanying species** in upper and lower storeys. The larger stand area the more emphasis is put on **uneven canopy (alternating thinner and denser patches)**. Interval of interventions 5-10 yrs.

→ Gradual removal of NS that have reached the target diameters. **Support of regeneration beginning of the other species** such as SF (regenerated 10 yrs in advance before expected NS crop diameters are reached) and BE regenerated below the mature NS.

→ The possibility of using group (structural) thinning.

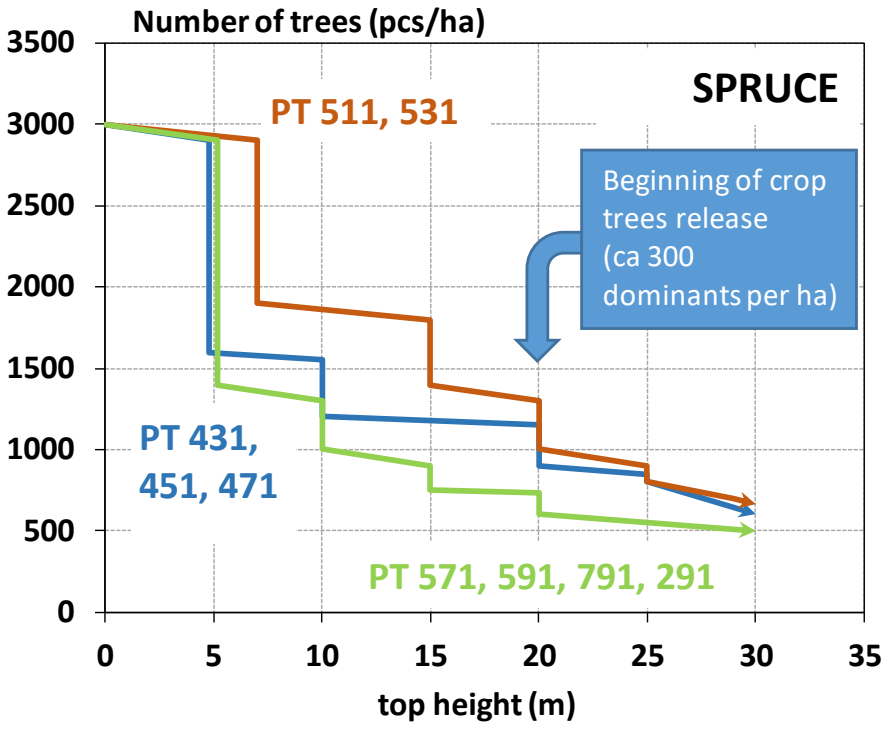

Figure 22 Orientation scheme of thinning models for spruce stands.

I.C

Stand types "spruce" (431, 451, 471, 511, 531, 571, 591, 791, 291)

Present status (type) **C – distant**

Regeneration:

- We can begin the regeneration also earlier (in 60th yr of age) – where there is a risk of rapid disintegration. When planning and conducting renewal cuts, **take account of NS stand present on the site maximally.**
- When clearcutting – use smaller cuts.

→ If unstable (high h/d ratio, short live crown), the stand should be thinned less intensively with a shorter period between the interventions.

→ Risk of weed infestation on nutrient rich or waterlogged sites.

- Conduct group or group-edge cuts **where patches of natural regeneration** (also around the individual parents) of trees already exist – preferably BE, SF and SP, OK, SY, EL, DF, NOM, EM, CAR, GAR, SBI, ROW, ASP).

→ When releasing desirable undergrowth, remove NS from the upper storeys preferably.

- **Underplant** SF (within the stand) and BE (inner strip), provided the parent stands are vigorous.
- In case of a rapid parent stand **disintegration risk**, **support and rely on pioneering species** (SP, ASP, SIB, ROW) and crop species regenerate below the preparatory stands.

→ Support all self-seeded desirable tree species.

→ Unstable uniform overaged NS stands **need to be quickly regenerated using strip felling with narrow clearcuts** on which intolerant desirable trees are to be planted.

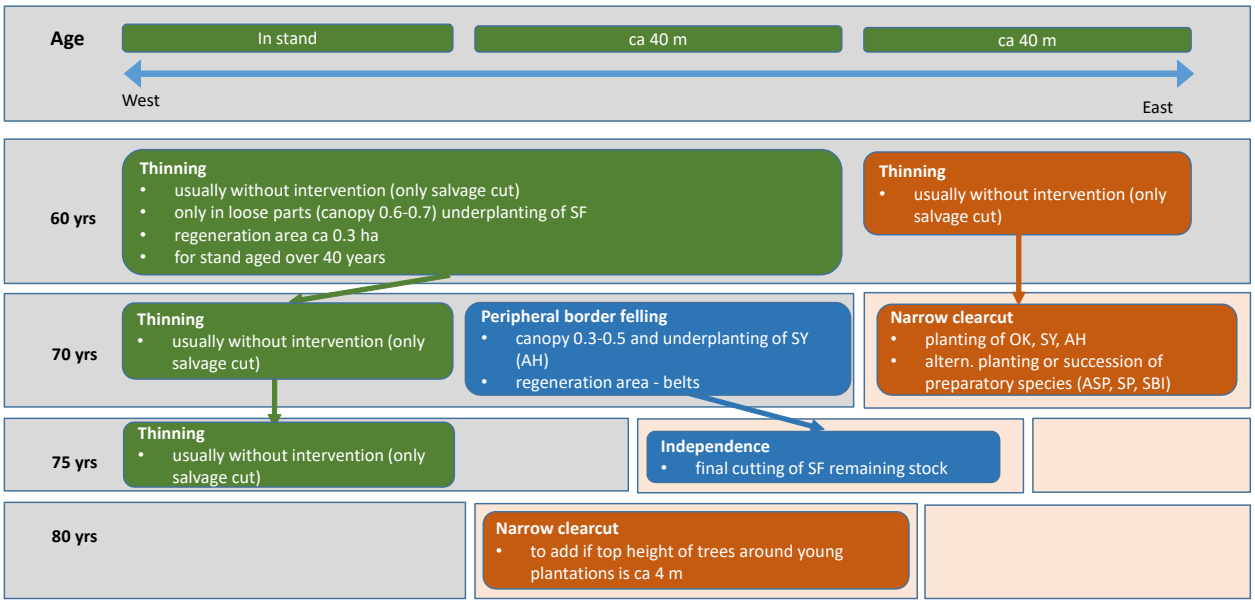

Figure 23 An example of the temporal and spatial sequence of regeneration of NS dominated stands to mixture with broadleaves (on sites with higher risk of NS cultivation) (modified according to Sachsenforst management principles).

Figure 24 Underplanting of beech (above) and fir (below) in spruce stands.

Tending:

Plantations (underplanting, undersowing) and advance growth

Same principles as for **transitional type** (sub-chapter. I.B on page 36), plus:

- **Additional regeneration of NS is not desirable.**
- To release undergrowth **more quickly compared to the B - transitional type** (BE when height of dominants is 4 m, SY, alternatively AH when the height is 2 m).

→ If not sheltered, the advance growth needs **heavy cleaning** (in NS also schematically – shrub cutter); all accompanying tree species should be supported maximally.

Stands younger than 40 years

- **If the first thinning is conducted appropriately** (before top height 7 m in PT 431, 451, 471, 511, 531 and top height 9 m in PT 571, 591, 791 a 291) – **follow the B - transitional type prescriptions** (sub-chapter I.B on page 36).
- **If no thinning was conducted** (before top height 10 m in PT 431, 451, 471, 511, 531 and top height 15 m in PT 571, 591, 791 a 291) **or the density after slight thinning exceeds** at top height 10 m density 1.4 thousand/ha in PT 431, 451, 471, at top height 10 m density 1.2 thousand/ha in v PT 571, 591, 791, 291 and at top height 15 m density 1.7 thousand/ha in PT 511 a 531, **heavy thinning approach is not allowed any more.**

→ Emphasis on development of larger live crowns in accompanying species following the release cut. Uniform NS stands can be thinned also schematically.

→ Light thinning from below consists in gradual removal of declining but still competing trees (high h/d ratio) – the intervention period 5-10 yrs. All other vigorous species than NS are beneficial.

Stands older than 40 years

- If thinned appropriately (NS dominants show h/d 60-80 with live crown sharing at least 50% of the stem) – follow the prescriptions f**or B – transitional type**. (sub-chapter I.B on page 36).
- Monospecific NS parts should not be thinned heavily in order to **prevent weed infestation** (on nutrient-medium soils) and **restrict NS regeneration** (up to 10% in PT 291, 20-30% in PT 431, 451, 471, 40-50% in PT 511, 531, 571, 591 and 70% in PT 791 can be tolerated).
- The stands too dense with inappropriate h/d ratio should be thinned from below (labile understory), upper storey should be thinned slightly in periods 5-7 yrs.

→ Emphasis on release cut (larger crowns expected) of the other trees, their support (also undergrowth) when thinned.

→ Gaps following salvage cut plant or regenerate naturally with desirable tree species.

Figure 25 Combined regeneration of target tree species in gaps after salvage cut. Here originally (ca. 20 years ago) the spruce thicket, partially destroyed by snow.

I.P

Stand types "spruce" (431, 451, 471, 511, 531, 571, 591, 791, 291)

Measures in stands damaged by biotic and abiotic agents (for all types - A, B and C)

Thorough **sanitation cut of trees infested by bark beetle**.

Stands damaged by game (bark browsing and peeling):

- Thickets – try to find **at least 300 trees per ha in the upper storey, which show no and/or slight damage – release** these (according to density) **and protect individually** in order to prevent damage.
- In stand with logs – **release minimally damaged crop trees**, remove the most injured trees.

→ Support every accompanying species, remove the most injured trees gradually, period of intervention no longer than 5 yrs.

→ Support natural regeneration in gaps following salvage-cutting or plant (also underplant) them with desirable tree species. Period of intervention no longer than 7 yrs.

Stands manifesting decline (yellowing, defoliation etc.)

- Advance growths manifesting yellowing in more than 50% trees – **do not use a schematic approach**, focus on **support of every healthy NS including the accompanying individuals**. At top height 2 m, reduce the density to 4 thousand per ha – remove preferably the all-damage trees.
- Thickets and small-pole stands – if at least 1.4 thousand healthy NS trees are present, reduce the density in PT 431, 451, 511 and 531 to ca 2 thousand per ha at top height 7 m and continue to 1.5 thousand per ha when top height is 15 m and in PT 471, 571, 591, 791 and 291 to 1.5 thousand per ha at top height 5 m and continue to 1.1 thousand per ha at top height 10 m.
- If less than 1.4 thousand trees per ha are present on the site, **support the healthiest 300-400 trees per ha**, release these from the nearest competitors.
- As pole stage is achieved, thinning of declining NS stands is risky – threat of sooner disintegration. If the stand contains a satisfactory share of accompanying species, support it maximally. Otherwise, a sanitation cut and conversion are conducted.

→ Support all healthy NS trees regardless of the storey they thrive in. Plant the gaps with desirable EL, DF, OK or leave them to SIB, ROW, ASP self-seeding.

→ Remove all moribund and crooked trees, support all other desirable species.

→ Leave other trees without intervention excepting support of accompanying species.

→ In case of a slower disintegration, all desirable tree species are underplanted and interplanted.

Figure 26 Support of healthy (undamaged by browsing and peeling) individuals in the upper storey.

II.A

Stand types "pine" (433)

Present status (type) **A – target**

Selection felling interventions according to criteria:

- **Sanitation selection** – salvage cutting at all growing stages.
- Support of quality and stability – in younger parts positive selection, i.e. **to release quality crop trees including maintenance of accompanying species**, in older parts prefer removal of low-quality competitors.

→ Support of admixed OK, BE by group selection, EL, DF by individual selection.

- **Support and maintenance** of target stand structure.

→ Alternating patches of different age with desirable species.

- **Harvest of "mature" trees** according to their development stage and management goals. In groups without SP adjust all interventions to the needs of all species present on the site; remove not only "crop", but **also undesirable competitors which hamper the development of the vertical canopy**.

→ Target diameter ranges between 35-50 cm.

- **Intervention intensity** (including salvage cut) in the context of total current increment accumulated following the previous intervention.
- Support of regeneration - **to release locally, in groups**.

→ Preferentially at sites where advance regeneration of desirable species is already present.

Figure 27 Especially in larger pine stands, it is desirable to support the natural regeneration of other tree species.

II.B

Stand types "pine" (433)

Present status (type) **B – transitional**

Regeneration:

- Conduct regeneration **within smaller patches with the regeneration period of up to 30 yrs.** Combination of shelterwood, strip and selection cut – **also shade-intolerant trees** (OK, SP, EL) thrive there.

→ In total – 2 interventions per 10 yrs (removal amounts ca 5-year increment of standing volume).

- To prefer all desirable species **natural regeneration below SP stands**. Soil scarification can be beneficial in seed years. In uniform SP stands, introduce BE, SF, SLI into shelterwood cuttings artificially, use EL for the repair planting.

→ Soil scarification can be used if possible.

→ **To initiate** regeneration below stand with **shade-tolerant trees** (SF, BE), add **tolerant trees** such as OK **later** in the final phase of the renewal.

- In case of small-area clearcutting, **leave** SP, SF and broadleaved **standards**.

→ **Adjust release cuts in shelterwood to the species needs** – intolerant trees have to be released quickly (maximally two phases), release the tolerant trees gradually (to the very final cutting of the SP stand).

Tending:

Plantations (underplanting, undersowing) and advance growth

- In young stands with gaps (exceeding 0.04 ha), **repair planting with crop species that are capable of stabilizing and soil-improving** (EL, DF, OK, SY) or support of pioneering species such as ROW, SBI and ASP.

→ **If sheltered** by a parent stand (upper storey), **release accompanying species** and conduct sanitation cut.

→ If **no shelter** above, advance growth should be **cleaned** (in SP also using a shrub cutter – schematic approach) **supporting** (even individually) **accompanying species**.

Stands younger than 40 years

- Intensive thinning from below in SP supporting individual stability and preventing short crowns – these should share at least 30% of the stem (see scheme).
- In larger groups, an uneven thinning intensity is beneficial (mosaic following site conditions, health and share of valuable species).

→ The accompanying species should be released at the expense of dominant SP.

→ At the same time **establish skidding lines** in appropriate density (4-5 m wide lines 30 m

Stands older than 40 years

- Shift to a positive approach – release ca 300 crop trees per ha from 1-2 competitors. Interval between interventions 5-10 yrs.
- Harvest of target-diameter SP prepares regeneration simultaneously – prefer groups, break canopy for underplanting, alternatively undersowing.

→ Support of mixed target species.

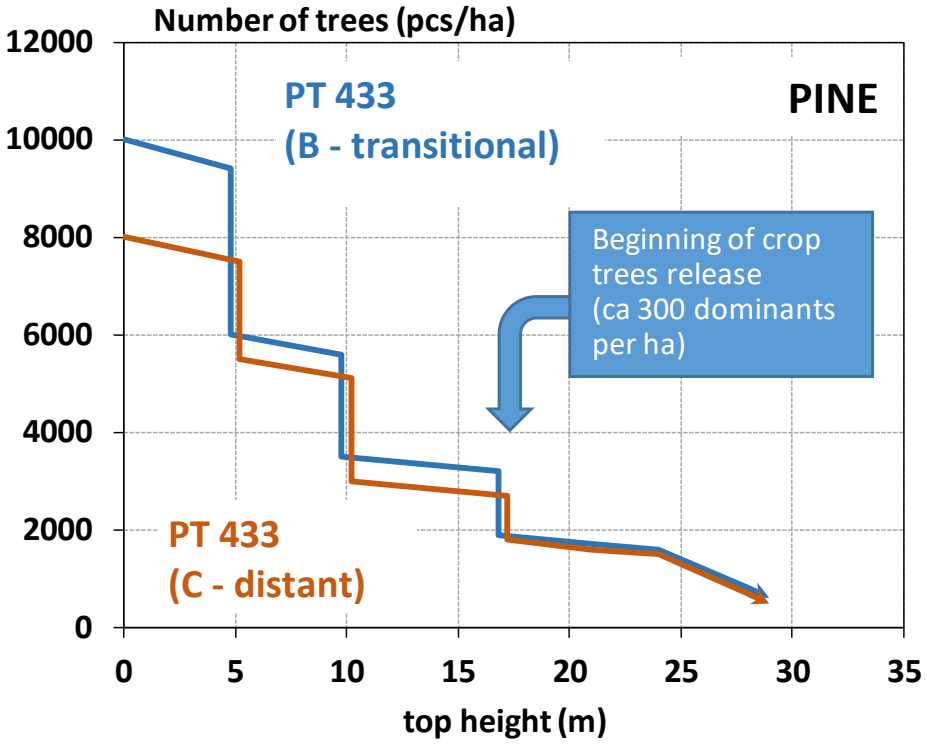

Figure 28 Orientation scheme of thinning models for pine stands.

Figure 29 Thinning in pine dominated stands should also lead to the support of admixture.

II.C

Stand types "pine" (433)

Present status (type) **C – distant**

Regeneration:

- To begin even earlier (in 60th year of age) – where there is a risk of faster disintegration. **Use strip and small-clearcuts**, if longer lifetime of stands is expected, BE, SF and SLI can be planted below groups with broken canopy. Planting of OK, DF, EL on clearcuts.

→ All **self-seeded desirable tree species** are beneficial.

→ **Divide larger stands into segments** where different tree species are preferred thus creating a mosaic mixture.

- If there is a **risk of faster disintegration**, SIB, ASP and ROW **self-seeding is beneficial** and crop trees are regenerated later.

Tending:

Plantations (underplanting, undersowing) and advance growth

Same principles as for **transitional type** (sub-chapter II.B on page 46), plus:

- **Additional regeneration of SP and NS is not desirable.**

→ If not sheltered, the advance growth needs **heavy cleaning** – intensive compared to transitional type (in SP also schematically – shrub cutter); all accompanying tree species should be supported maximally.

Stands younger than 40 years

- **Intensive thinning** from below in SP **supporting individual stability** and releasing other tree species – also from understory (see scheme).
- **If the stands have not been thinned** (no intervention before top height 10 m **or these were thinned so slightly** that density is 4.2 trees per ha), the **intensive approach is no longer beneficial**.

→ **Other principles** as for **transitional type** B.

→ The stands should be thinned slightly from below removing dying trees and understorey competitors (inappropriate h/d ratio); intervention return is every 5-10 yrs. Support all vigorous accompanying species.

Stands older than 40 years

- **If thinning was conducted appropriately** (SP dominants show h/d 80-100, live crowns share at least 30%) – **see basic prescriptions for B-transitional type** (sub-chapter II.B on page 46).
- In dense stands with inappropriate h/d ratio, **remove labile trees from understorey**, in main storey apply slight intensity thinning every 5-7 yrs. Gaps of salvage cut origin can be either planted or naturally regenerated with desirable tree species.

→ Emphasis on released accompanying species in order to maintain their large crowns and support their natural regeneration already in the stage of thinning.

→ Monospecific SP parts should not be released too much – weed control (nutrient-medium site) and do not support SP regeneration (30-40% share can be tolerated).

II.P

Stand types "pine" (433)

Measures in stands damaged by biotic and abiotic agents (for all types – A, B and C)

Stands damaged by game (bark browsing and peeling):

- Thickets – try to find **at least 300 trees per ha in the upper storey, which show no and/or slight damage – release** these (according to density) **and protect individually** in order to prevent damage.
- In stand with logs – **release minimally damaged crop trees**, remove the most injured trees.

→ Support every accompanying species, remove the most injured trees gradually, period of intervention no longer than 5 yrs.

→ Support natural regeneration in gaps following a salvage-cutting or plant (also underplant) them with desirable tree species. Period of intervention no longer than 7 yrs.

The stands threatened by drought

- **Reduce density** of advance regeneration and young thickets (reduces interception and number of transpiring trees.
- Where SP stands have NS understorey, remove the NS at once.

Figure 30 In stands damaged by snow, irregular canopy opening can be used for combined regeneration of target species.

III.A

Stand types "oak" (435)

Present status (type) **A – target**

Selection felling interventions according to criteria:

- Sanitation cut in all growing stages.
- Support of quality – in younger parts combined approach, i.e. remove wolf trees and release quality trees, in older parts support crop trees preferentially.

→ Support of accompanying species (groups more appropriate).

- Support and maintenance of target structure.

→ Alternating larger patches of different age and different desirable species.

- **Harvest of "mature" trees** according to their development stage and management goals.
- In groups without OK, adjust all interventions to the needs of all species present on the site; **remove undesirable competitors** which hamper the development of the vertical canopy.

→ Target diameter ranges between 50-70 cm.

- **Intervention intensity** (including salvage cut) in the context of total current increment accumulated following a previous intervention.
- **Support of regeneration** – release in larger groups (0.5 ha) **when seed years are expected**.

Figure 31 Canopy opening in larger groups supports natural regeneration.

III.B

Stand types "oak" (435)

Present status (type) **B – transitional**

Regeneration:

- Conduct regeneration using **shelterwood strip felling with shelterwood groups** placed ahead, enlarge these using peripheral felling.

→ Two-phase shelterwood – the first phase is seed cutting including appropriate soil scarification.

→ The second phase is final cutting where 3-4 years old advance growth of 0.5 m height is released.

- **Segment the stand appropriately** in order to proceed the regeneration as quickly as possible, differentiate species composition of desirable species.

→ In case of regeneration failure, it is necessary to plant OK of local origin within renewal patches of 0.5 ha minimally.

Tending:

Plantations (underplanting, undersowing) and advance growth

- **Reduce density** of advance growths (risk of development of inappropriate h/d ratio in OK and damage by snow load).
- **Where there are gaps** in juvenile stands (over 0.04 ha), conduct repair **planting or support self-seeding of desirable stabilizers or soil improvers** (EL, DF or SY, SLI).

→ Both naturally regenerated and planted OK – remove wolf trees first and support OK at the expense of fast-growing competitors such as SBI and ASP.

Stands younger than 40 years

- **Start** at top height 5 m (see scheme).
- Initiate and maintain desirable understorey of SLI and other shade-tolerant species (SF and others).

→ At the same time, **establish skidding lines** in appropriate density (4 m wide lines 30 m apart).

Stands older than 40 years

- Further release of crop trees.

→ Segmentation of stands to regenerate them – group mixture of the other species where OK is missing.

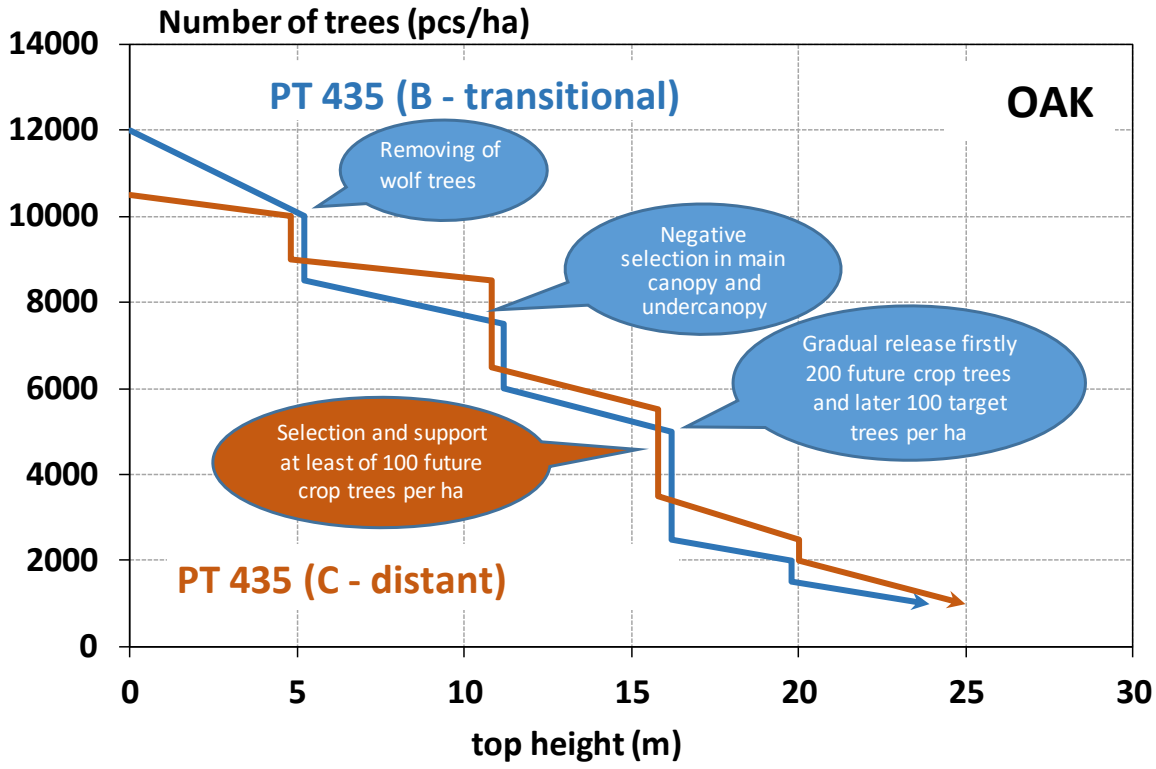

Figure 32 Orientation scheme of thinning models for oak stands.

Figure 33 The release of OK target individuals must lead to preservation of sufficiently large crowns.

III.C

Stand types "oak" (435)

Present status (type) **C – distant**

Regeneration:

- **Two-phase shelterwood**. Plant the missing desirable species (BE, SF, SLI) into groups placed ahead or within inner edge of strip.
- **Support self-seeded** species.

→ In the first seed cutting conduct soil scarification.

→ **Larger stands segment** and prefer particular tree species in order to get a mosaic – mix of groups.

- The **worse the parent OK stand**, the **quicker** should be its regeneration – also prefer other desirable species.

Tending:

Plantations (underplanting, undersowing) and advance growth

Same principles as for **transitional type** (sub-chapter. III.B on page 52), plus:

- **Support for all other** target tree **species.**

Stands younger than 40 years

- Negative intervention in all stand parts – **reduced density promotes increment**. Take care of **100 crop trees** – release them from 1-2 competitors.

→ To **release** accompanying species, **also under canopy**.

→ At the same time, **establish skidding lines** in appropriate density (4 m wide lines 30 m

Stands older than 40 years

- Release crop trees continually.

→ Focus on **promotion of larger live crowns of accompanying species** and initiation of their natural regeneration already during thinning the stands.

III.P

Stand types "oak" (435)

Measures in stands damaged by biotic and abiotic agents (for all types – A, B and C)

Remove heavily damaged and weakened trees. In stands older than 100 yrs when stocking dropped below 0.5, initiate their regeneration.

Stands threatened by drought:

- Maintain lower storey of broadleaves (SLI, HBM, SBI, ASP, NOM), which supports microclimatic maintenance of soil moisture and nurses OK (self-pruning).

Figure 34 The aim of the thinning of oak stands is also the initiation and support of the second floor of other tree species.

IV.A

Stand types "beech" (436, 476)

Present status (type) **A – target**

Selection felling interventions according to criteria:

- **Sanitation selection –** salvage felling at all growing stages.
- Support quality – **in younger parts, remove wolf trees and release quality trees** including desirable group admixture; **in older parts, focus on crop trees**.

→ Support of admixed species – group selection is more appropriate.

- **Support and maintenance** of target stand structure.

→ Alternating patches of different age with desirable species.

- **Harvest of "mature" trees, group selection** according to the condition and management goals.
- In groups without BE, adjust all interventions to the needs of all species present on the site; **remove undesirable competitors** which hamper the development of the vertical canopy.

→ Target diameter ranges between 40-60 cm.

- **Intervention intensity** (incl. salvage cut) based on the total current increment accumulated following the previous intervention.
- **Support of regeneration** – release in larger groups (0.5 ha) **when seed years are expected**.

Figure 35 The goal in BE stands is the differentiation of groups of different ages.

IV.B

Stand types "beech" (436, 476)

Present status (type) **B – transitional**

Regeneration:

- Use 4-phase shelterwood cutting.
- Underplant SF as small groups. In the last phase, OK is allowed to be planted. Leave standards of desirable species.
- The stand should be **appropriately segmented** to differentiate desirable species composition.

→ Modify the stocking as follows: 8 – preparatory cutting, 6 – seed cutting, 3 – release cutting and finally remove shelter above 0.5 m high advance growth.

→ Timing of phases 1 and 2 coincides with seed years. The number of phases can be lower depending on the cutting rate.

Tending:

Plantations (underplanting, undersowing) and advance growth

- Remove wolf trees in BE advance growths and plantations.
- Where there are **gaps in juvenile stands** (over 0.04 ha), conduct **repair planting or support self-seeding of desirable stabilizers or soil improvers** (EL, DF, OK or SY, SLI).

Stands younger than 40 years

- **Start** at top height 5 m (see scheme).
- No intervention in understorey.

→ At the same time, **establish skidding lines** in appropriate density (4 m wide lines 30 m apart).

Stands older than 40 years

- Continue **releasing 130-200 crop trees** per ha every 5-10 yrs.

→ Support stand segmentation to get group mixture where BE is missing.

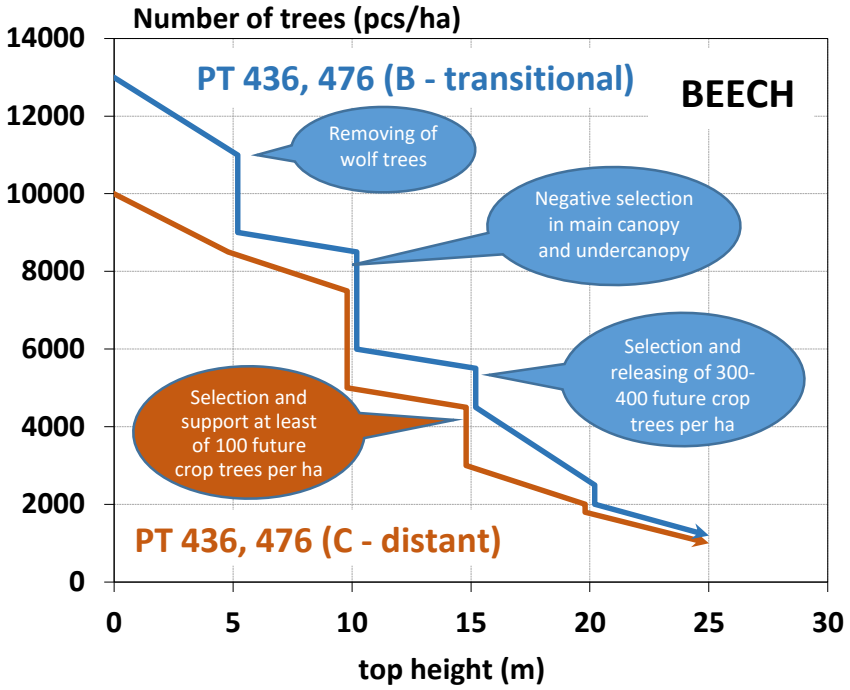

Figure 36 Orientation scheme of thinning models for beech stands.

Figure 37 Support promising individuals by removing 1-2 competitors.

IV.C

Stand types "beech" (436, 476)

Present status (type) **C – distant**

Regeneration:

- Prioritize **strip felling for faster regeneration** and the possibility to more actively change the species composition towards CDS.
- **Missing species** (SF, SLI) **by artificial regeneration** in advanced groups or inner edges of the strips.
- For open areas of light-demanding species of CDS (EL, OK, DF, SP).

→ Support self-seeded species from target composition.

→ **Larger stands segment** and prefer particular tree species in order to get a mosaic – mix of groups. Support self-seeded species.

- **The worse the parent BE stand, the quicker should be its regeneration** – also prefer other desirable species.

Tending:

Plantations (underplanting, undersowing) and advance growth

Same principles as for **transitional type** (sub-chapter. IV.B on page 58), plus:

- **Support for all other** target tree **species.**

→ To **release** accompanying species, **also under canopy**.

Stands younger than 40 years

- Remove undesirable trees – support increment by reduced density (see scheme).
- Take care of at least 100 promising trees – release them from 2 competitors

→ At the same time, **establish skidding lines** in appropriate density (4 m wide lines 30 m apart).

Stands older than 40 years

- Continue releasing crop trees (at least 50 per ha).

→ Focus on releasing accompanying species to promote larger live crowns and support their natural regeneration already during the last thinning.

IV.P

Stand types "beech" (436, 476)

Measures in stands damaged by biotic and abiotic agents (for all types – A, B and C)

Support any accompanying species to prevent disintegration of forest stands over large areas.

Support by releasing fertile individuals for maximum use of the natural regeneration of BE to the share of approx. 50% on HS 436 and approx. 10% on HS 476. Even in heavily damaged stands, keep viable BE standards for the possibility of natural regeneration.

Figure 38 Young BE stands heavily damaged by ungulate game.

V.A

Stand types "broadleaved – alder" (597)

Present status (type) **A – target**

Selection felling interventions according to criteria:

- **Sanitation selection –** salvage felling at all growing stages.

- Support quality – **in younger parts, remove wolf trees and release quality trees** including desirable group admixture; **in older parts, focus on crop trees**.

→ Support of admixed species – group selection is more appropriate.

- **Support and maintain** the target structure.

→ Alternating larger multi-age groups of desirable species.

- **Harvest of "mature" trees, group selection** according to the condition and management goals.
- In groups without CAR, adjust all interventions to the needs of all species present on the site; **remove undesirable competitors** which hamper the development of the vertical canopy.

→ Target diameter ranges between 40-60 cm.

- **Intervention intensity** (incl. salvage cut) based on total current increment accumulated following the previous intervention.

- **Support of regeneration** – release in larger groups (0.5 ha) **when seed years are expected.**

Figure 39 Natural regeneration creates high-quality alder stands.

V.B

Stand types "broadleaved – alder" (597)

Present status (type) **B – transitional**

Regeneration:

- Use strip felling in combination with group shelterwood cutting. Leave standards (species according to CDS) on strips.
- Support of natural regeneration of CAR, alt. by sprouts – possible to use them as preparatory stands for other species (SF).
- The stand **should be appropriately segmented** to differentiate desirable species composition.

→ Underplant SF as small groups in forward (shelterwood) parts. BE is possible to use on drier places.

→ NS regenerate only naturally up to 20 %.

Tending:

Plantations (underplanting, undersowing) and advance growth

- **Remove wolf and forked trees** in CAR advance growths and plantations.
- **Where are gaps** in juvenile stands (over 0.04 ha), conduct **repair planting or support self-seeding of desirable stabilizers or soil improvers** (OK, AH).

Stands younger than 40 years

- **Start** at top height 5 m (see scheme)
- No intervention in understorey after top height 15 m.

→ At the same time, **establish skidding lines** in appropriate density (4 m wide lines 30 m apart).

Stands older than 40 years

- Continue **releasing 150-200 crop trees** per ha every 5-10 yrs.

→ Support stand segmentation to get group mixture where CAR is missing.

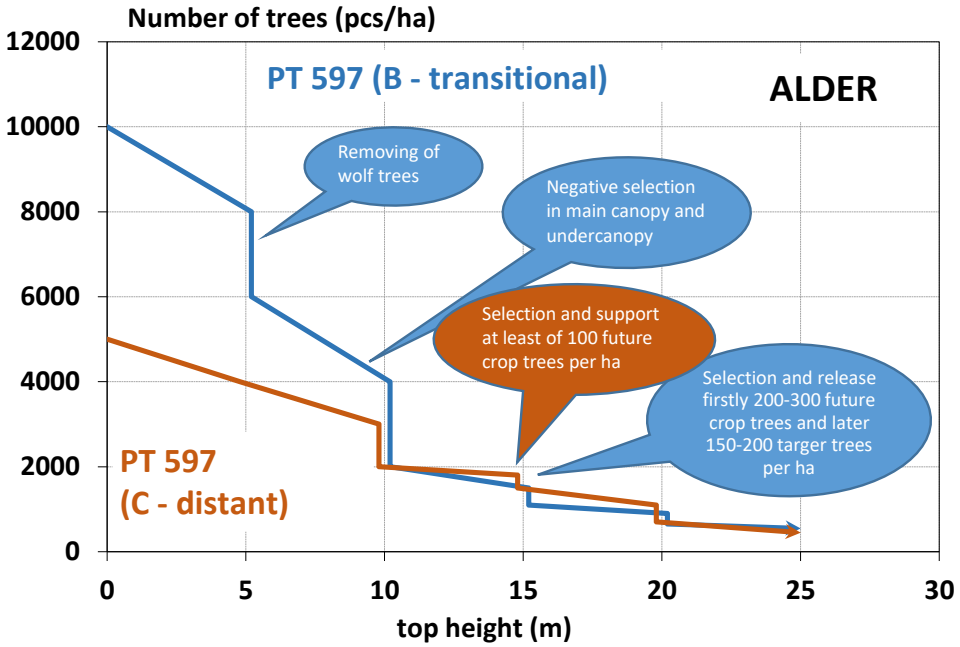

Figure 40 Orientation scheme of thinning models for alder stands.

Figure 41 Promising alder individuals with straight stem should be released during thinning interventions.

V.C

Stand types "broadleaved – alder" (597)

Present status (type) **C – distant**

Regeneration:

- Prioritize **strip felling for faster regeneration** and the possibility to more actively change the species composition towards CDS.
- **Missing species** (SF, SY) **by artificial regeneration** in advanced groups or inner edges of the strips.
- For open areas of light-demanding species of CDS (primarily OK).
- **Initialization and support of the second layer in monospecific CAR parts** – desiccation function.

→ **Support self-seeded species** from target composition.

→ **Larger stands segment** and prefer particular tree species in order to get a mosaic – mix of

- **The worse the parent CAR stand**, **the quicker** should be its **regeneration** – also prefer other desirable species.

Tending:

Plantations (underplanting, undersowing) and advance growth

Same principles as for **transitional type** (sub-chapter. V.B on page 64), plus:

- **Support for all other** target tree **species.**

Stands younger than 40 years

- Remove undesirable trees – **support increment by reduced density** (see scheme). Take care of a**t least 100 promising trees – release them** from 1-2 competitors – prevent shortening of the crown.

→ To **release** accompanying species, **also under canopy**.

→ At the same time, **establish skidding lines** in appropriate density (4 m wide lines 30 m apart).

Stands older than 40 years

- Continue releasing crop trees (at least 50 per ha).

→ Focus on releasing accompanying species **to promote larger live crowns** and support their natural regeneration already during the last thinning.

V.P

Stand types "broadleaved – alder" (597)

Measures in stands damaged by biotic and abiotic agents (for all types – A, B and C)

Support any accompanying species to prevent disintegration of forest stands over large areas.

Figure 42 Natural differentiation takes place in young alder stands, but it is desirable to encourage their growth by reducing the density.

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7. MONITORING, EVALUATING THE EFFECTIVENESS OF MEASURES AND CORRECTIVE MEASURES

The extent to which browsing or other factors (light, precipitation, soil, ground vegetation, seed abundance) affect the development and structure of regeneration can be analysed in more detail using the method of fenced control plots. The development of regeneration within the fenced plots (not affected by browsing) and the regeneration areas of the same species without fencing are compared. Intensity of browsing is determined by a large number of factors. In addition to game population density, game distribution and migration opportunities, there are effects of forest structure, hunting intensity and load on the forest linked to its recreational function. All these factors are in mutual direct or indirect relationships with many layers.

7.1. Method of control fenced plots according to the Saxon method

7.1.1. Selection of forest stands

The forest stands shall be selected with particular attention. Special emphasis is put on the impact of cloven-hoofed game on the development of natural regeneration in representative stands characteristic of the respective forest district. Such a stand type is selected, while taking into account the following: species composition, soil type, reproductive potential (i.e. presence of seed trees, etc.). The stands selected are those where regeneration measures are planned for the next 15 to 20 years. These should also be at least 1 ha in size to avoid distortion by the stand edge. The stocking rate shall range between 7 and 8. The state of the regeneration plays a decisive role. It is ideal to locate the pair of control plots where regeneration is already in progress or where it is anticipated. It is not suitable to locate these where regeneration exceeds 70 cm in height. The optimal baseline situation is a regeneration height of around 20 cm. The method is generally applicable in natural regeneration.

7.1.2. Plot selection

When the fenced and unfenced plots are selected within the selected stand, two circular plots with the same habitat and regeneration are determined (100 m^2, 5.64 m radius), and regeneration inventory is carried out. The selection of plots is decisive for the successive comparison of their pairs. The mentioned regeneration inventory ensures that the pair of plots to be compared is selected objectively according to the site and regeneration conditions. Irregular distribution and varying density of the emerging regeneration are taken into consideration. Furthermore, the proportion of tree species in both plots can be identified. This also reflects the influence of cloven-hoofed game. It shall be noted that in the first survey, the initial situation must be documented carefully, as all subsequent measurements relate to it. It is therefore crucial for the whole method.

Marking the plots in the field – one tree on the unfenced plot is marked with capital "V", while one tree on a fenced plot will bear capital "Z", in both cases accompanied with an arrow towards

the marker pole. The fence and the control plots shall be 12 x 12 m. Both of the plots shall be subject to identical management. This applies to both the harvest and tending in regeneration.

7.1.3. Measurement

Measurements are carried out in May, both on fenced and unfenced plots. When the survey is repeated, the date should be as close as possible to the date of the original measurement. The measurement is carried out by a respective forest worker.

7.1.4. Assessment of control plots

The individual control plots along with the inventory of regeneration provide information on the forest stand conditions. By combining several pairs of plots, an assessment for larger territorial units is obtained. The aim of the analysis is to compare the development of regeneration and vegetation on fenced and unfenced plots and to monitor the development of regeneration based on its inventory. We may expect 3 following outputs:

- no impact of game (no difference)
- negative impact of game (significantly better development of regeneration on the fenced plot)
- positive effect of game

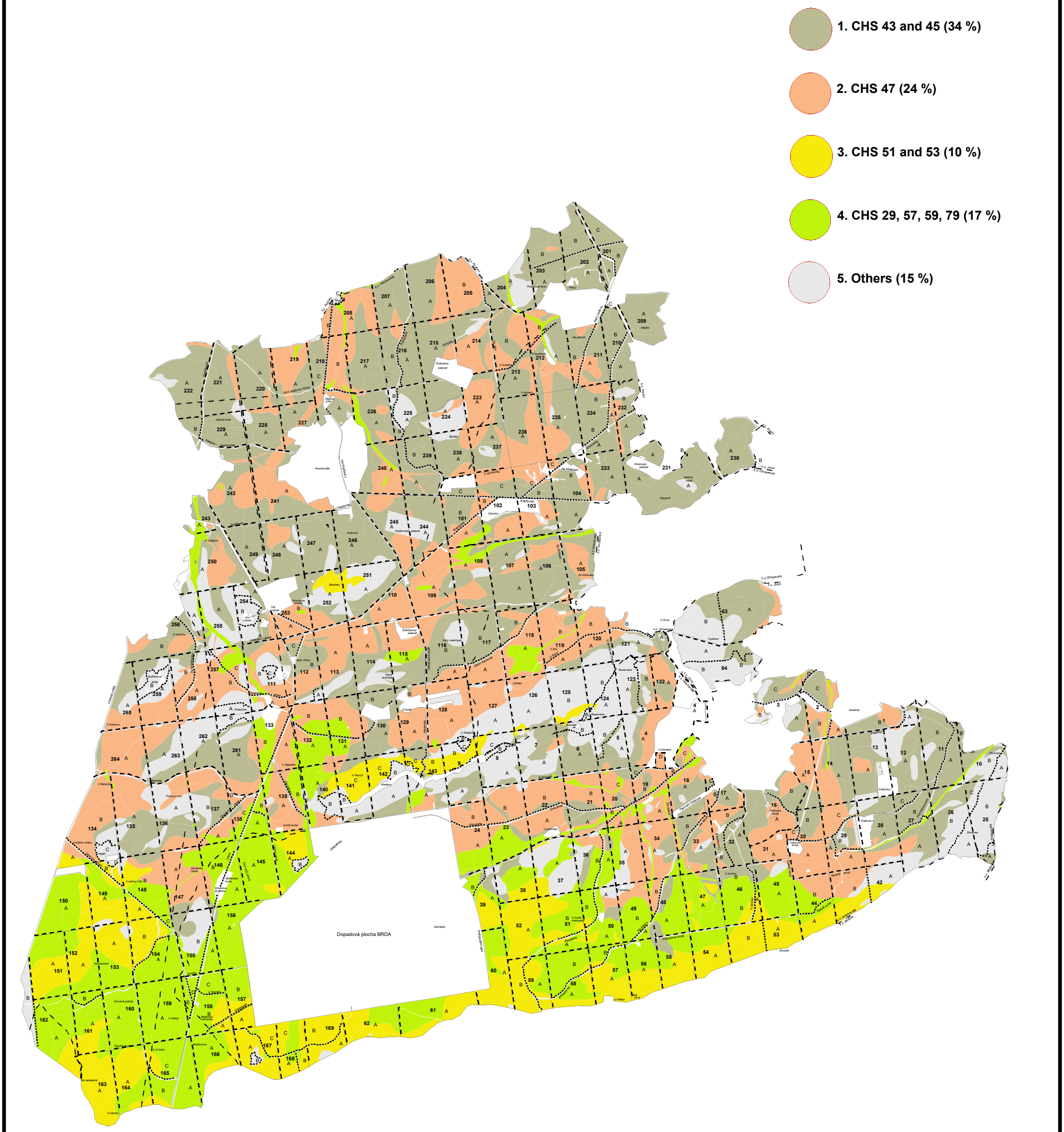
❖ *Detailed information on the establishment of plots, measurement and assessment are given in the document: Hunting Management Concept for the Brdy Hunting Ground (Project 101074426-LIFE21-CCA-CZ-LIFE Adapt Brdy)*

Figure 43 Control fenced plots for monitoring of game damage and natural regeneration

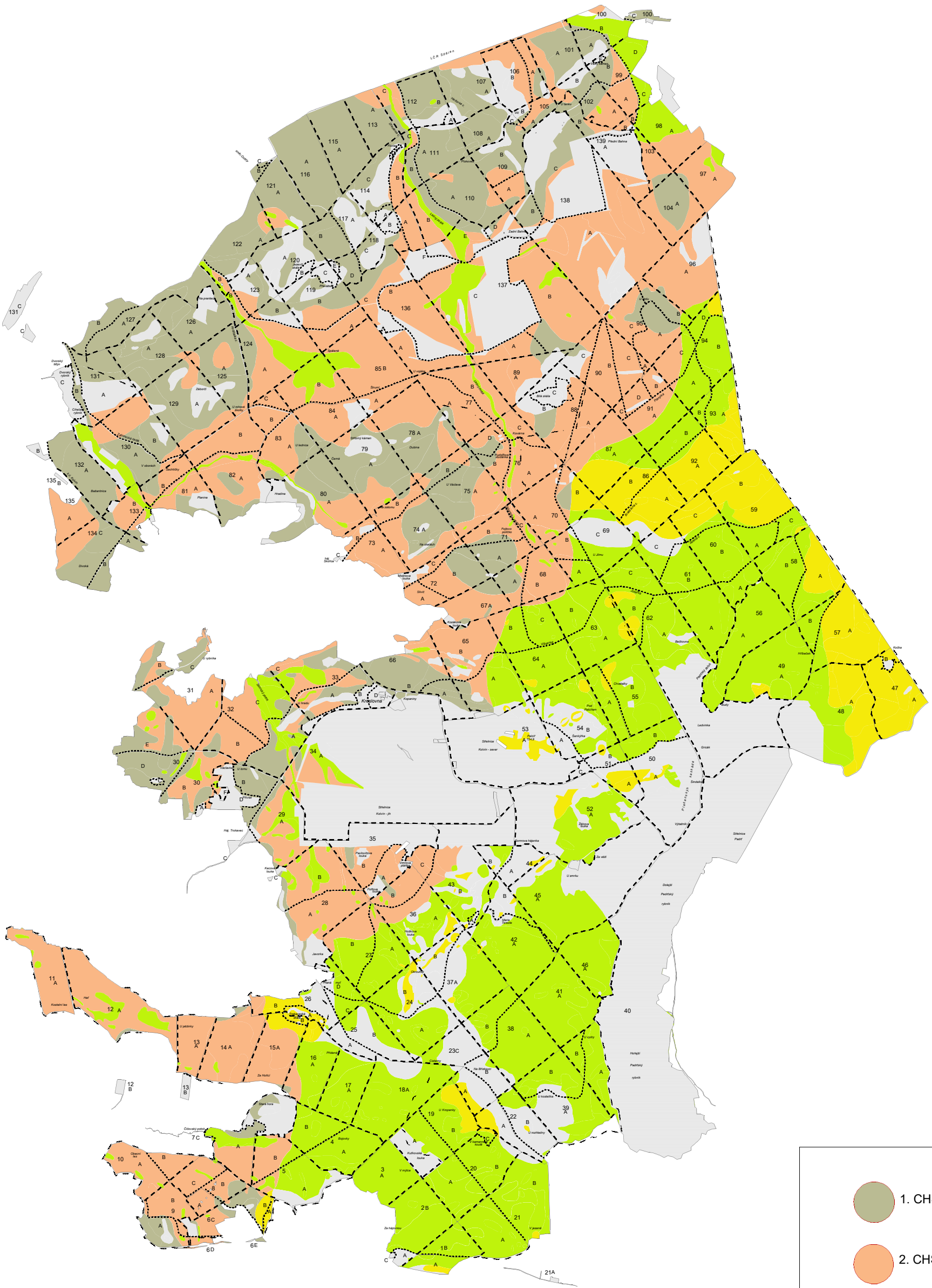
8. ANNEXES

8.1. Graphic overview of forest development types according to FMPA

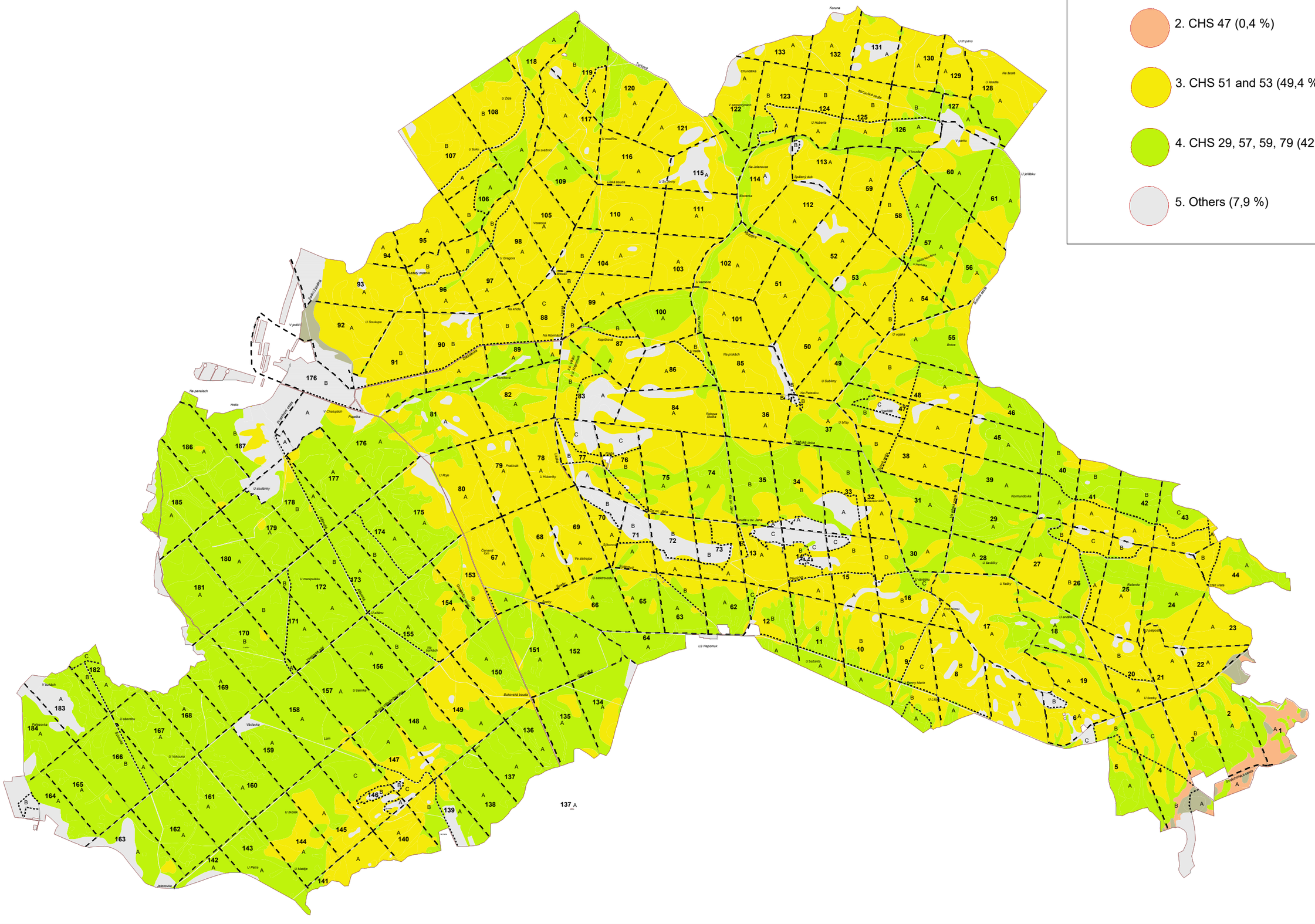
Target management units (CHS) in FMPA Jince (11121)



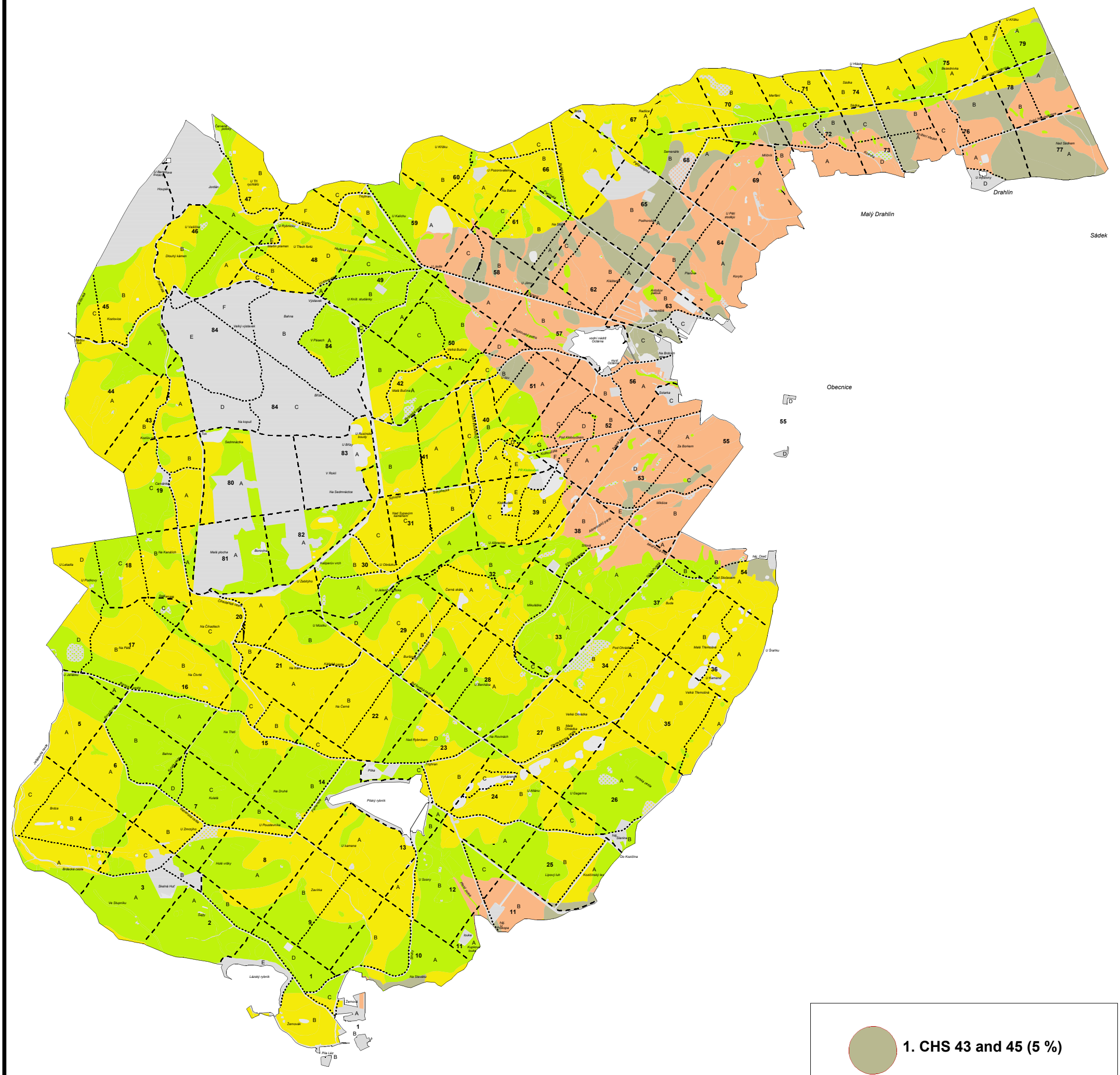
Target management units (CHS) in FMPA Mirošov (11422)



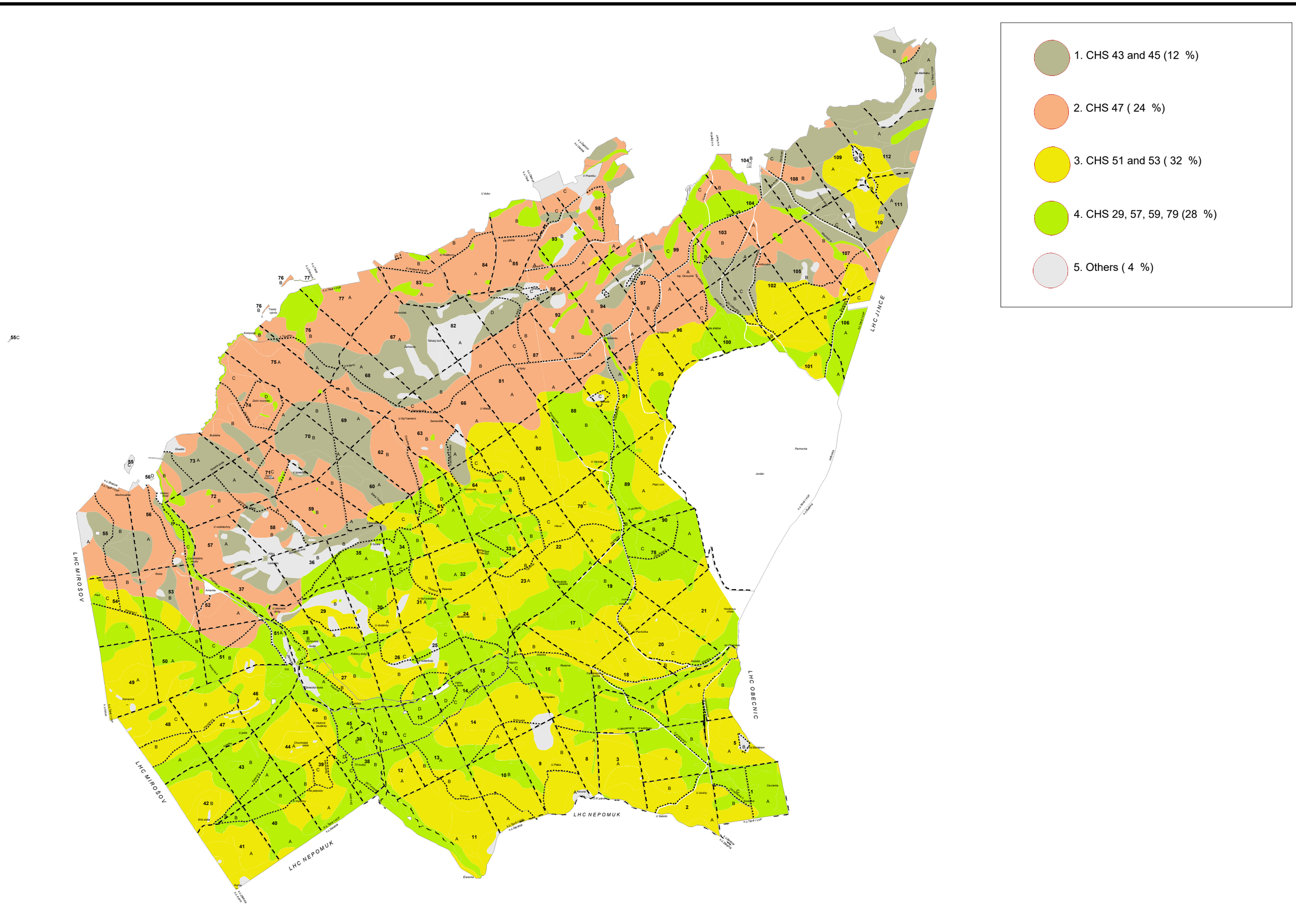
Target management units (CHS) in FMPA Nepomuk (11319)



Target management units (CHS) in FMPA Obecnice (11224)



Target management units (CHS) in FMPA Strašice (11522)



8.2. Photographs – individual stand types

Figure 44 Stand type – distant

Figure 45 Stand type – transitional

Figure 46 Stand type – target