

## Deliverable 1.1 – FMM descriptions (in report form)

Project Title	Alternatives models and robust decision-making for future forest management
Project Acronym	ALTERFOR
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Project Duration	1 April 2016 – 30 September 2020
Project Duration in months	54
Authors, organizations (short name)	Main authors: Eric Agestam and Urban Nilsson, SLU Co-authors: local case coordinators
WP No., WPL(s)	WP1, Urban Nilsson and Eric Agestam
Date of delivery by Coordinator	07 June 2017
Date of delivery according to DoA	31 May 2017
Reviewed by	Project coordinator, scientific coordinator, administrative coordinator
Type of Deliverable	
Report	X
Demonstration	
Websites, patents, fillings, etc.	
Dissemination level	
Public	X
Confidential, only members of the consortium (including the Commission Services)	
Other	

# I. Forest Management Models (FMMs) description



## 5. Lithuania

### 5.1. Background and forest history

The Lithuanian forestry is young by the European standard, the national forest administration only emerged after establishing the Republic of Lithuania in 1918. The new country inherited forests that were quite severely depleted by noble landlords during the rule of the Tsar Russia 1795–1915. The Lithuanian forestry of the interwar period (1918–1940) was primarily shaped by: (i) development of forestry institutions (organizations, practices, etc.) by returnee nationals educated in Russia and Germany and accordingly influenced by respective forestry schools; (ii) land reform during which most forests were nationalized, resulting in domination of State forests and (iii) the economic necessities of the poor agrarian country, where forests were an important natural resource both for needs of rural population (fuel, timber of building) and for the national economy through in-comes from timber exports. Essentially, the interwar forestry was struggling to hit a reasonable balance between establishing ordered silvicultural practices (adequate regeneration, tending, etc.) and maintaining rather intensive utilization (Brukas 2015).

During Soviet occupation (1940, 1944-1990) Lithuania was one of 15 Soviet republics under Muscovite command economy with all its particularities including a complete ban of private forest property. Planned economy relied on strict managerial hierarchies as generally as in forestry. Planners had a heavy say on what should be done by state forestry enterprises in terms of cutting norms and silvicultural measures. As elsewhere in Eastern Europe, forest management system in Lithuania had its ideological base in the classical theory of normal forests. The silvicultural ideal to strive after was productive stands that by the end of the (sufficiently long) rotation can deliver the highest possible amount of timber of sawlog dimensions. In addition, forest management should aim at achieving an even forest age class distribution to ensure the evenness of timber flow. Forest management planning was set up accordingly with strict rotation ages and area control of age classes. Important additional features were the introduction of forestland zoning by forest functions (practices applied in the whole USSR) and the attempt by the Lithuanian authorities to save the (previously depleted) domestic resources due to the possibilities of timber shipments from the Russian Federation (Brukas 2015).

The restoration of independence in 1990 brought radical economic, ideological, and institutional changes at multiple levels inevitably challenging the forestry subsystem. Among the most salient examples, the transition to market economy exposed forestry to market pricing of timber as well as production inputs; forest ownership restitution to pre-war landowners and their heirs was commenced in 1994, leading to the current ownership structure: 50% state forests; 40% private forests and 10% reserve for restitution. These developments did not lead to relaxation of forest regulation and planning. Rather on the contrary, the regulatory clout was enlarged due to substantial increase of environmental consideration. The latter was caused by changing public

preferences, international influences (Rio 1992, signing international agreements, joining the EU in 2004) and powerful national patrons of environmental cause (Brukas 2015). This led to considerable expansion and refinement of forestland zoning resulting in 4 so-called forest groups:

I – strict reserves (1% of the total forest land);

II - special purpose forest with primary function of either environmental conservation or recreation (12%);

III – protective forests for protection of soils, water, etc. (15%);

IV – commercial forests with primary function of timber production (71%).

Also in commercial forests additional environmental stipulations were introduced, e.g. concerning biodiversity trees, seasonal harvesting restrictions, etc. Further restrictions of different degrees apply in groups I-III (Brukas et al. 2013).

Measured by the total forest area the extent of private forests came close to state forestry. However, the forest policy arena is strongly dominated by state forestry institutions, especially by the policy-formulating Forest Department under the Ministry of Environment and the state forestry coordinating Directorate General of State Forests. State forests (1 million ha) are managed by 42 state forest enterprises with average forest area of 25,000 ha. Private forests (0.83 million ha) are managed by 250,000 owners, a private forest estate averaging 3.3 ha. Voluminous forest-related legislation treats state forest enterprises and private forest owners largely identically despite the huge differences in respective aims and management conditions. On average managing 25,000 ha, state forest enterprises have by far superior prerequisites for following the legislated forest management paradigm. Facing stringent control, private forest owners largely comply with overarching legislative requirements (such as minimum allowable rotation ages), however, the actual approaches to forest management are highly diverse, reflecting the diversity of ownership objectives (Stanislovaitis et al. 2015). Following the traditional forest management paradigm, majority of forests are under even-aged management system with long rotations and rather small-sized clear cuts (averaging about 2 ha in size). Silviculturally preferred species are conifers (Scots pine and Norway spruce) and noble broadleaves (Oak and Ash). In reality, the management intensity (in terms of planting and thinning regimes) is much lesser than prescribed, especially in private forests.

## 5.2. General description of CSA

The main features of the CSA is that diversity of Lithuanian forest management conditions are represented here, even they are not proportionally distributed:

Table 20. Data about Lithuania and the Lithuanian CSA

Preconditions for managing forests*	CSA	Lithuania
Total area	253 971 ha	6 528 600 ha
Forest land area	88 195 ha	2 179 895 ha
Proportion of forest land area	34.7 %	33.4 %
Forests under state ownership	33 799 ha 38.3 %	1 084 517 ha 49.8 %
Private, reserved for restitution and other forests	54 396 ha	1 095 378 ha

Preconditions for managing forests*	CSA	Lithuania
	61.7 %	50.2 %
Private forest land area	43 812 ha	832 104 ha
Number of private forest owners	10 372	247 825
Number of private land parcels	14 279	290 094
Forest land area per private land parcel	3.1	2.9
Forest groups:		
Reserves forests (I)	2.1 %	1.6 %
Forests for protection of ecosystems (IIA)	14.3%	9.7%
Recreational forests (IIB)	0.9%	3.0%
Protective forests (III)	25.1%	14.6%
Commercial forests (IV)	57.6%	71.1%
Gross annual increment	6.4 m <sup>3</sup> /ha	7.0 m <sup>3</sup> /ha
State forests managed by state forest enterprises and national park other forests	6.6 m <sup>3</sup> /ha	7.4 m <sup>3</sup> /ha
Average stand age (all forests)	54 years	56 years
State forests managed by state forest enterprises and national park other forests	52 years	52 years
Average stand age (mature forests)	85 years	87 years
State forests managed by state forest enterprises and national park other forests	64 years	67 years
Average site class index	11.2	1.6
State forests managed by state forest enterprises and national park other forests	1.8	1.4
Average stocking level	0.69	0.74
State forests managed by state forest enterprises and national park other forests	0.68	0.73
Growing stock volume (all forests)	193 m <sup>3</sup> /ha	229 m <sup>3</sup> /ha
State forests managed by state forest enterprises and national park other forests	204 m <sup>3</sup> /ha	230 m <sup>3</sup> /ha
Growing stock volume (mature forests)	271 m <sup>3</sup> /ha	312 m <sup>3</sup> /ha
State forests managed by state forest enterprises and national park other forests	232 m <sup>3</sup> /ha	257 m <sup>3</sup> /ha

Notes:

The area and cover of forestland is based on the international definition of forest, while productive forestland have a production potential of > 1m<sup>3</sup>ha<sup>-1</sup>year<sup>-1</sup>. This distinction is of high practical importance because forest management is not allowed in unproductive forests

(<1m<sup>3</sup>ha<sup>-1</sup>year<sup>-1</sup>). The coverage of the different FMMs described in this questionnaire are therefore expressed as their coverage on productive forestland.

The annual increment values in m<sup>3</sup> ha<sup>-1</sup> yr<sup>-1</sup> are provided below by tree species (they were estimated based on actual data from stand-wise forest inventory; all forests of the CSA. Should be noted, that area weighted average values were calculated for all soil type x main tree species combinations not accounting for other stand characteristics, like actual tree species combination,

basal area and other stand attributes. Calculations done using standard functionality of State Forest Cadaster IS):



Table 21. Site productivity  $m^3ha^{-1}y^{-1}$  different sites, calculated on actual data from stand inventory in Lithuanian CSA

	Productivity/soil moisture	Dry	Mesic	Moist	Wet
High productivity:	Norway spruce	8.26	6.68	5.8	7.39
	Scots pine	9.63	7.11	-	-
	Birch spp.	6.89	7.17	6.02	6.08
	Grey alder	6.89	7.03	7.07	6.09
	Black alder	5.51	6.36	6.96	7.01
	European aspen	7.38	7.9	4.84	6.54
	Pedunculate oak	5.41	5.29	-	-
	Ash	4.47	4.26	4.79	-
Medium productivity	Norway spruce	9.16	7.93	7.38	6.56
	Scots pine	9.04	7.88	6.64	5.64
	Birch spp.	7.51	7.61	6.06	5.16
	Grey alder	6.9	7.55	6.83	5.95
	Black alder	6.41	4.84	6.93	6.08
	European aspen	6.46	7.87	6.35	5.88
	Pedunculate oak	5.72	5.06	-	-
	Ash	5.07	4.64	-	-
Low productivity	Norway spruce	8.88	8	7.01	5.92
	Scots pine	7.87	7.55	5.68	3.65
	Birch spp.	6.6	6.13	4.59	3.3
	Grey alder	-	-	-	-
	Black alder	-	-	7.91	3.56
	European aspen	-	8.49	5.39	-
	Pedunculate oak	-	-	-	-
	Ash	-	-	-	-

### 5.3. Tree species in Lithuania and in the CSA

The proportion of the total volume refers to all tree species in the compartment (forest stand), however the proportion of area refers to the main tree species in the compartment (the last option is important in defining the FMM). Only compartments covered by forest stands in forestland are included. Non-forestland being grown with the forest was not included. The country level statistics were obtained from Forestry statistical yearbook 2015, published by State Forest Service.

The proportion of Norway spruce is larger in the CSA than in the country, contrary, the Scots pine seems to be under-represented in the CSA, which is primarily due to relatively rich forest soils, prevalent on the CSA. Also we can note relatively larger shares of Grey alder and Pedunculated oak and a smaller share of Black alder in the CSA than in the country.

Table 22. Tree species, % of standing volume and % of forest area in CSA and Lithuania, [\\*http://www.amvmt.lt/images/veikla/stat/miskustatistika/2015/01%20Misku%20ukio%20statistika%202015\\_m.pdf](http://www.amvmt.lt/images/veikla/stat/miskustatistika/2015/01%20Misku%20ukio%20statistika%202015_m.pdf)

Species (Latin name)	Proportion (% total volume)		Proportion (% of area as main species)	
	CSA	Lithuania*	CSA	Lithuania*
Norway spruce ( <i>Picea abies</i> )	36.7	21.2	33.8	20.9
Scots pine ( <i>Pinus sylvestris</i> )	20.6	36.6	18.5	35.0
Birch spp. ( <i>Betula</i> - <i>Betula pendula</i> or <i>Betula pubescens</i> )	20.3	16.3	24.7	22.3
Grey alder ( <i>Alnus incana</i> )	6.5	4.2	8.4	6.1
Black alder ( <i>Alnus glutinosa</i> )	4.5	8.6	4.8	7.3
European aspen ( <i>Populus tremula</i> )	5.7	6.3	4.6	4.1
Pedunculate oak ( <i>Quercus robur</i> )	4.0	2.8	3.8	2.1
Ash ( <i>Fraxinus excelsior</i> )	0.5	1.0	0.5	1.2
Small-leaved lime ( <i>Tilia cordata</i> )	0.3		0.2	
Norway maple ( <i>Acer platanoides</i> )	0.4		0.4	
Elm ( <i>Ulmus glabra</i> )	0.1		0.1	
Goat willow ( <i>Salix caprea</i> )	0.3		0.1	
Other ( <i>Larix</i> , <i>Carpinus betulus</i> , <i>Salix</i> , <i>Populus</i> , <i>Quercus rubra</i> etc.)	0.1		0.1	

#### 5.4. Generally about FMMs used in CSA and in Lithuania

Currently, there are 12 FMMs in the list covering 93.7% of the CSA. Long rotation uniform shelterwood cutting in pine forests on dry low productivity soils (Labanauskas felling) will not be investigated in more details due to small share and low experience of local foresters to utilize it. There were some attempts to apply it by forest company Telsiai SFE, however they did not manage to reach natural regeneration sufficient for re-establishment of pine stands.

Majority of FMMs applied in Lithuania are represented in CSA. As the Scots pine is the most common tree species in Lithuania, which is represented in much less proportions in CSA, the long rotation forestry in coniferous forests is under-represented. Clear cutting in pine forests can be easily discussed, unfortunately there is not good material for so called Labanauskas felling. This type of felling is applied on dry low productivity near pure pine stands removing part of the main layer and leaving the stand for natural regeneration. In some areas this FMM results satisfactory results in mixed pine-spruce stands, however it has never succeeded in Telsiai SFE. Nevertheless, there are numerous studies conducted or on-the-way in Lithuania, thus we may expect to use materials out-side CSA to define this FMM. Next, Norway spruce dominated stands are present in larger proportions in the CSA than may be expected in the whole country.



Table 23. The FMM used in CSA and in Lithuania, and % of area in CSA, in state forest in CSA and in Lithuania

Forest Management Model (FMM)	Corresponding silviculture system	Coverage CSA (% forest-land)	Share of state forests %	Coverage country (% forest-land*)	Main tree species
Medium rotation clear cuttings in coniferous forests ( <i>spruce</i> ) MRCON_C	Clear-felling system	14.6	51	10	spruce
Medium rotation non-uniform shelter-wood / clear cuttings in coniferous forests ( <i>spruce</i> ) MRCON_CUS	Non uniform shelterwood system/clear-felling system	9.9	40	5	spruce
Long rotation clear cutting in coniferous forests ( <i>pine</i> )	Clearfelling system	7.4	41	8	pine
Long rotation uniform shelter-wood / clear cutting in coniferous forests ( <i>pine</i> ) LRCON_CUS	Uniform shelterwood system/clear-felling system	5.0	51	6	pine
Medium rotation non-uniform shelter-wood in coniferous forests ( <i>spruce</i> ) MRCON_US	Non uniform shelterwood system	3.7	47	2.5	spruce
Long rotation uniform shelter-wood in coniferous forests (Labanauskas felling) ( <i>pine</i> ) LRCON_US	Uniform shelterwood system	2.9	47	15	pine
Medium rotation uniform shelter-wood / clear cutting in deciduous forests ( <i>birch &amp; black alder</i> ) MRDEC_CUS	Uniform shelterwood system/clear-felling system	12.7	23	13	birch & black alder
Medium rotation clear cutting in deciduous forests ( <i>birch &amp; black alder</i> ) MRDEC_C	Clear-felling system	10.2	31	10	birch & black alder
Short rotation uniform shelter-wood / clear cutting in deciduous forests ( <i>aspen &amp; grey alder</i> ) SRDEC_CUS	Uniform shelterwood system/clear-felling system	7.5	10	6	aspen and grey alder
Short rotation clear cutting in deciduous forests ( <i>aspen &amp; grey alder</i> ) SRDEC_C	Clearfelling system	3.2	11	3	aspen and grey alder
Management in special purpose forests	Non uniform shelterwood system	13.4	62	12.2	
No intervention	No intervention	3.2	95	2	

Total:		93.7	38.3	92.7	
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Table 24. Ecosystem services for FMMs in Lithuanian CSA.

Forest Management Model (FMM)	Most common/ important ES	Second most important	Notes (“also”)
Medium rotation clear cuttings in coniferous forests ( <i>spruce</i> ) MRCON_C	Timber production		Secure biodiversity protection and provision of environmental protection and recreational and carbon sequestration services
Medium rotation non-uniform shelter-wood / clear cuttings in coniferous forests ( <i>spruce</i> ) MRCON_CUS	Timber production	Fuel wood supply	Ibid. (cf. MRCON_C)
Long rotation clear cutting in coniferous forests ( <i>pine</i> )	Timber production		Ibid.
Long rotation uniform shelter-wood / clear cutting in coniferous forests ( <i>pine</i> ) LRCON_CUS	Timber production.		Ibid.
Medium rotation non-uniform shelter-wood in coniferous forests ( <i>spruce</i> ) MRCON_US	Timber production		Ibid. The importance of other ESs is higher than in other Spruce dominated stands of CSA. Fuel wood supply.
Long rotation uniform shelter-wood in coniferous forests (Labanauskas felling) ( <i>pine</i> ) LRCON_US	Timber production		Ibid
Medium rotation uniform shelter-wood / clear cutting in deciduous forests ( <i>birch &amp; black alder</i> ) MRDEC_CUS	Timber production	Fuelwood supply	Ibid.
Medium rotation clear cutting in deciduous forests ( <i>birch &amp; black alder</i> ) MRDEC_C	Timber production	Fuel wood supply	Ibid.
Short rotation uniform shelter-wood / clear cutting in deciduous forests ( <i>aspen &amp; grey alder</i> ) SRDEC_CUS	Fuelwood production		Ibid. Timber supply in some cases.
Short rotation clear cutting in deciduous forests ( <i>aspen &amp; grey alder</i> ) SRDEC_C	Fuelwood production		Ibid. Timber supply may be considered to be important in European aspen stands, not damaged yet by the stem rot and under conditions of sufficient demand for the wood for packaging.
Management in special purpose forests	Sustaining and recovering of forest ecosystems or their specific components	Recreation on ~5% of the FMM area.	
No intervention (Reserves)	Biodiversity protection and biosphere monitoring		

### 5.5. Other FMMs used in Lithuania

Long rotation clear cuttings in deciduous forests, mainly dominated by noble deciduous tree species, like pedunculated oak and ash, covering ~1.6% of the CSA. Very long rotations are applied there – MARA for oak is 121 and 141 years in group IV and III, respectively and the methodology for estimating the allowable cutting amount requires that all mature oak forests are cut no less than in

30 years (for ash – 20 years). This requirement is applied for state forests and extends the rotation period significantly. Around 1.4% of the area is covered by oak and ash dominating stands, which may be cut both using clear or shelter-wood systems, as well as there are 0.7% of noble deciduous stands with clear final felling prohibited due to location of the stand (e.g. inside the Zemaitija National park, along the main roads or surrounding some reserves). Going beyond the CSA – oak and ash dominated stands in group III-IV forests cover around 3% of the country's forest area.

There are 1.9% of birch and black alder and 0.8% of aspen and grey alder stands, for which the uniform shelter-wood systems is mandatory due to the location of the stand (see above). Otherwise, these stands are managed similarly to respective uniform shelter-wood – clear cuttings systems, except that clear felling is not allowed.

Additionally, even not present currently, plantation forestry is expected to play an important role in CSA. Plantations are expected to be established in the areas outside the current forest land.

## 5.6. General information for all FMMs in the Lithuanian CSA

### *Origin of tree species and tree breeding*

No non – native European species are used in the CSA today. There have been very limited tests of lodgepole pine, (*Pinus contorta*) but not anymore.

Species used are native to Lithuania. But there is a discussion whether European larch (*Larix decidua* subsp. *polonica*, which is the most common larch in Lithuania) should be considered native or non-native to Lithuania. Some larch trees were planted during last decade both in state and private forests. Otherwise, only local tree species are used.

The general approach is to use locally collected seeds. Birch seeds mostly are collected more than 100 km from the CSA aiming to get higher selection values stands than present locally.

Seeds are sometimes purchased from neighbouring SFEs, sometimes more than 100 km distance, due to insufficient amounts collected locally and following the requirement to have a reserve of seeds for up to 7 years. Birch seeds were purchased because of aiming to use seeds collected in higher selection values stands than present locally. Seeds are stored in a special seed storage place near Kaunas for all SFEs. Birch seeds are not collected locally.

### *Genetically improved*

Seeds used in artificial regeneration, in absolutely most cases planting, are collected in stands belonging to the 1st selection group, which are identified by officers of State Forest Service. Seeds may not be collected in other stands. The national forest sector development program requires by 2020 more than 50% of seeds (for coniferous) for planting material to be collected in seed plantations.

### *Hybrids and genetically modified trees*

No hybrids are used so far, but there is an interest to use hybrid aspen (*Populus tremula x tremuloides*) in models for short rotation clearcutting in deciduous trees.

No genetically modified regeneration material is used in the Lithuanian CSA.



### *Use of herbicides/pesticides and fertilizers*

Herbicides (Roundup FL) are used to prepare the clear-cut areas, relevant only for some managing models, for artificial regeneration, on high and medium productivity soils (total area on ALL FMM, state forests managed by Telsiai SFE) – 2013 – 59.6 ha; 2014 – 17.8 ha; 2015 – 23.7 ha.

Repellents (3 different brands) to protect regeneration are used in areas with spruce and pine planted (1-4 years from planting annually) in the areas with denser game population soils (total area on ALL FMM – 2013 – 600 ha; 2014 – 577 ha; 2015 – 502 ha). Also, seedlings are treated in nurseries as is treated timber in storage places.

No information is available from private forests about use of herbicides and pesticides, however, herbicides (Roundup FL) are usually used in private forests if regeneration of clear cut areas is carried out by contractor (i.e. not by the owner himself). Most likely for preparation of clear-cut areas for artificial regeneration.

No fertilizers are used in the Lithuanian CSA.

### *Fencing*

Regeneration areas are only fenced in case of planted Scots pine, oak and larch no matter what forest management method. This is about 10% of the artificially regenerated areas, in total small areas are fenced, 2016 2ha of Scots pine plantation.

### *Size of stand and clearfelled areas*

Many of the forest management models used in Lithuania are clearcutting systems. Forest cutting rules in Lithuania require the maximum clear-cut area not to exceed 8 ha (commercial forests, i.e. group IV) or 5 ha (protective forests, group III).

The width of clear-cutting area shall not exceed 150 m (100 m in group III forests) on dry soils and 100 m (75 m in group III forests) on other soils. This limit may be expanded by 1.5 times if attempting to match the borders of clear-cut area with the borders of forest compartments, nevertheless the clear-cut area limit shall not be violated. The width of clear-cut area may not be followed in low density stands or if the clear-cut area is under 3 ha (5 ha in over-mature stands). Also, the clear-cut width limitation does not apply in stands, located in restricted areas, state parks and biosphere reserves if whole forest compartment is to be harvested and the total area limit is not violated. The width of clear-cut area on steep slopes (15°-45°) shall not exceed 75 m. The longer edge of clear-cut area shall follow North-South orientation. If there is a need to follow the direction of forest block network, the clockwise deviation from the North-South orientation shall not exceed 25° and anti-clockwise deviation - 45°. Clear-cut areas shall be allocated moving against prevailing wind directions, i.e. from the East to the West, and adjacent area needs to be cut not earlier than 5 years and it needs to be reforested and the height of targeted tree species shall be not less than 0.5 m. Maximal length of clear-cut area is 1 km. The width of uncut forest belt between clear-cut areas planned to be cut the same year shall at least twice (one time in over-

mature stands or in forest tracts under 20 ha) exceed the width of the clear-cut area. There is also requirement that clear-cutting area shall not exceed 20% of the land parcel size in isolated forest tracts, smaller than 15 ha in protected areas.

If no clearcutting occasional cuttings is applied, there are no limitations for this FMM regarding the area to be harvested at one-time point.

### **Influences on rotation period**

For private owners there are no regulations about length of rotation periods. For State forest the rotation period is defined in the Forest Cutting Rules, approved by Minister of Environment by the minimum final cutting age (<https://www.e-tar.lt/portal/lt/legalAct/TAR.4A966C7D30EB/myILxRuchG>)

The minimum final cutting age in spruce stands was 60 years in Lithuania before the WWII.

There were several studies conducted a decade ago suggesting differentiation of maturity age based on soil and site productivity properties. According to (Brukas et al. 2001), minimum allowable rotation age (MARA) for spruce on typical sites and using different estimation approaches is:

Forest rent: 75 years

SEV with 2 or 3% discount rate: 65 years

SEV with 4%: 60 years

SEV with 5%: 55 years

For Scots pine on typical sites and using different estimation approaches is:

Forest rent: 80 years

SEV with 2 discount rate: 65 years

SEV with 3%: 60 years

SEV with 4%: 55 years

SEV with 5%: 50 years

Deltuvas et al., 2003 suggested the economic maturity age for pine stands to be dependent on the site index: 70-80 years for IA-I sites (making 51% of the FMM area) and 80-90 for II-III sites (31% of the FMM area) and 110-120 years for IV-V sites (remaining 18%). They also suggested technical maturity ages based for sawn logs – 70-80 and 90-100 years for site types IA-I and II-III, respectively, as well as financial maturity ages based on present net value (80-90 (IA-III), 110-120 (IV-V)) and soil expectation value – 70-80 (IA-I), 80-90 (II-III) and 110-120 (IV-V).

The same considerations were also provided for clear cutting based FMM on Norway spruce dominated stands.

In principle, the rotation periods suggested by some experts are slightly shorter than the ones applied in practice. Especially, it should be noted, that due to specifics in establishment the allowable cutting amount, even longer rotation periods are applied in state forests than one could guess based on the minimum final cutting age – in spruce stands by 15 years. This leads to accumulation of mature forest stands, losing the timber quality (significant amount of over 70 years

old spruce stems contain some rot) and permanent harvesting priorities on over-maturing forest. This could be explained by the forestry approaches which have developed during the Soviet period and have not been changed yet - the aspiration to preserve domestic forest resources and shipping significant amounts of timber from the Russian Federation. Up to some extent reduction of rotation period is avoided due to political reasons and willingness to look more environment friendly in the eyes of society. Discussion on alternative rotation periods is considered to be taken into consideration while elaborating alternative FMMs in ALTERFOR.

### 5.7. Medium rotation clearcutting in coniferous forest (spruce) MRCON\_C

The most common forest management model in the Lithuanian CSA is clearfelling models for coniferous, mainly spruce. Today is used on 14.6% (only the area of forest stands is taken into account), 51% of this area belongs to state.

This FMM could be considered as the most attractive for the CSA. Dry and mesic medium fertility soils suitable for spruce stands and outside the areas with additional environmental restrictions and without high potential for natural regeneration cover around 21% of the forest land. Currently, this FMM model is “competing” with models involving clear cutting in medium rotation deciduous forests on similar soil conditions.

Even though the artificial regeneration aiming for spruce stands is costlier than the natural regeneration, the yield is around 1.7-2 times larger in spruce than in birch. Some mixed birch stands, currently assigned to FMM with non-clear or clear cutting at the maturity age, could be in fact clear felled and artificially regenerated to become spruce stands (as the establishment of spruce stands via non-clear cutting is rather difficult).

Current share of this FMM is lower than it could be expected, basically due to the fact that Norway spruce is often replaced by trivial (i.e. not noble) deciduous tree species and thus assigned different FMMs with different rotations. The share of Norway spruce has decreased notably during last two decades first of all due to bark beetle and wind damages. Open gaps in the former spruce stands were filled by softwood deciduous trees, sometimes also by younger spruce trees making the 2nd spruce layer. The common practice is to prioritize planting Norway spruce stands to be harvested later by clear cutting. The exception is the areas with root rot (*Heterobasidion annosum*) in a stand of previous generation – then deciduous species may replace spruce. Also, this FMM is the most attractive for natural conditions of the CSA – there are some planted Norway spruce stands under 20 years with volume more than 200 m<sup>3</sup>/ha.

#### *Edaphic conditions*

This model is mainly used on medium productive sites on dry and mesic soils.

#### *Ecosystem services*

The main ecosystem services from this model is timber production. Forest management shall also secure biodiversity protection and provision of environmental protection and recreation and carbon sequestration services.

#### **Tree species and mixtures**



The model is mainly used for Norway spruce stands. Previously the mono-cultures were prioritized without taking into consideration that mixed spruce stands is more resistant to unfavourable factors. Today pure stands of spruce can only be accepted in stands smaller than 1ha. Instead the aspiration should be to avoid spruce monocultures. The ideal spruce stands to be clear cut should have 75-94% of spruce volume with some share of more mixed stands (focusing on the main ecosystem service, which is timber production). Actual stands are more mixed than the ideal, i.e. the majority of stands have 50-74% spruce. This is much explained by increased share of trivial tree species especially in younger age. Proper management (i.e. thinning cuttings) should move the actual condition towards the ideal one, especially increasing the share of spruce from 50-74% to 75-90%.

The tree species to be used in addition to the Norway spruce are provided below according to the edaphic condition type for commercial forests, group IVA (based on Re-forestation and afforestation rules):

Dry - medium: Scots pine, larch spp., Pedunculated oak, Norway maple, Small-leaved lime, European beech, Sessile oak (*Quercus petraea*), birch spp.

Mesic – medium: Scots pine, birch spp., Norway maple, small-leaved lime, pedunculated oak, European aspen, black alder

Mesic – high: Birch spp., European ash, Pedunculated oak, Sessile oak (*Quercus petraea*), Black alder, Norway maple, Small-leaved lime, European aspen.

The Re-forestation and afforestation rules suggest tree species which are not present currently in stands managed by current FMM (European beech, Sessile oak). The list of tree species includes some low commercial value trees, like Goat willow, Salix, grey alder, which are in very small amounts and make the tree species diversity richer.

In the Norway spruce prevailing stands other tree species share the volumes (%):

Norway spruce ( <i>Picea abies</i> )	80.0
Birch ( <i>Betula - B. pendula or B. pubescens</i> )	9.2
Scots pine ( <i>Pinus sylvestris</i> )	4.8
European aspen ( <i>Populus tremula</i> )	1.9
Pedunculate oak ( <i>Quercus robur</i> )	1.8
Grey alder ( <i>Alnus incana</i> )	0.7
Black alder ( <i>Alnus glutinosa</i> )	0.7
Ash ( <i>Fraxinus excelsior</i> )	0.1
Goat willow ( <i>Salix caprea</i> )	0.1
Small-leaved lime ( <i>Tilia cordata</i> )	0.1
Norway maple ( <i>Acer platanoides</i> )	0.1
Also present are larch ( <i>Larix</i> ), hornbeam ( <i>Carpinus betulus</i> ), <i>Salix</i> , <i>Populus</i> , <i>Ulmus laevis</i> , other hard-wood deciduous	

### **Regeneration**





Regeneration is normally done by planting, approx. 2/3. During the last decade in spruce stands natural regeneration share in state forests was 25%, while in private forests 70%. Should be noted, that in private forests were numerous clear cut areas recorded as non-reforested. Also, local forest nursery did not sell at all Norway spruce plantings to private forest owners during last year. Also should be noted, that the volume harvested in private spruce forests exceeded the volume harvested in state owned spruce forests.

For the future planting is suggested to 65-75%. The different figures depend on the type of forest ownership – state owned forests are managed following current silvicultural requirements and prioritize artificial regeneration. Private forest owners seem to be attempting to save on the forest regeneration.

Natural regeneration in this FMM in state forests is much dependent on the competence and professionalism of local forest district manager. However, opinion of Telsiai SFE is that within this FMM clear cutting and artificial regeneration need to be prioritized assuming the targeted ES which is timber production.

#### **Site preparation**

Site preparation is done on 100% if artificial regeneration is applied in state forests. No information available on soil preparation in private forests. Most likely, some private forest owners, especially if using services of third parties, apply the soil preparation.

Soil scarification shall be done always if artificial regeneration is applied. Planting Norway spruce has always been associated with soil preparation. No need for scarification if natural regeneration is applied

#### ***Stand management***

##### **Pre-commercial thinning**

According to the data from stand-wise forest inventory, 50 % of stand 11-20 years old in state forests have been pre-commercially thinned (PCT) in the period 2006-2015). In private forests, only approximately one stand of ten have been PCT. Also should be noted, that the same stand could be thinned before 2006 and planned to thin during coming decade. Thus, the area where pre-commercial thinning is applied at least once during the rotation period is much below 100% in private forests, how-ever each state owned stand is thinned more than once.

Pre-commercial thinning should be carried-out on average ~2.5 times in artificially regenerated stand and ~1.5 time in every naturally regenerated stand in order to develop spruce dominated stand (opinion of forest management planning expert from SFIMPI, they follow this requirement when planning the pre-commercial thinning during the process of elaborating internal forest management plan for the state forest enterprise). On this FMM, the first PCT takes place usually at the age of ~7 years. In ~5 years the aspen and birch are back. Thus, share of the area where stands are pre-commercially thinned at least once during a rotation period should be 100% in this FMM.

##### **Commercial thinning**



According to the data from stand-wise forest inventory, the commercial thinning was applied and recorded during the period 2006-2015 on 57% of the area and having age 25-44 years in state owned forests (16% in private forests). The commercial thinning in state owned stands over 44 years old was applied and recorded during the last decade on 26% of the area (16% in private forests). The area where commercial thinning is applied at least once during the rotation period is below 100% in private forests, however each state owned stand is thinned more than once.

There are 2 types of commercial thinning applied in Lithuania, which are later referred to as “1st commercial thinning” (“retinimai” in Lithuanian) and “2nd commercial thinning” (“einamieji kirtimai” in Lithuanian). Commercial thinning in this FMM is carried-out in 21-60 years old stands and must be done at least 2 times.

Private forest owners tend to avoid even the commercial thinning, most likely due to short-term economic consideration (i.e. avoiding the costs for thinning and limited incomes from the timber harvested). The ratio between the 1st commercial and 2nd commercial thinning conducted during the last decade and recorded by the stand-wise forest inventory in state owned forests is 1:0.2, while in the private forests it is 1:1.35. Even accepting the potential omission error in inventory data, there is a clear tendency that private forest owner tends to avoid less the 2nd commercial thinning, most likely due to increased amounts of commercial timber to be harvested.

### **Pruning**

Pruning is not relevant

### **Harvest**

Around 70% of harvesting is done using harvesters in state owned forests. Harvesters are used in private forests less than 50% of cases. In state forests – Telsiai SFE has its own harvester and the chain saws are used basically by harvesting contractors in areas with more unfavourable conditions for harvester. However, according to the experts from Telsiai SFE, sometimes the use of harvester may result in loses of 7-8 m<sup>3</sup>/ha of timber due to mistreating the stump part of the log. Also, the use of harvester is associated with more soil damages, however it is more cost efficient and nowadays the harvesting contractors are lacking

Wood extraction to 100% mechanized, using forwarders. However, some private forest owners for own timber utilization may not use fully mechanized wood extraction. Telsiai SFE extracts using own equipment 85-90% (all FMMS).

### **Use of logging residues**

At present there is no demand for logging residues, Telsiai SFE has not sold anything in the market for biofuels. The extraction of logging residues becomes unprofitable if the extraction distance starts to exceed 300 m and the amount of residues collected in one spot is under 25 m<sup>3</sup>. However, the expert from Telsiai SFE suggest using the same chassis for chipping and chip transportation equipment as for the forwarders. However, the biofuel produces and buyers prefer not to go off the road.

### ***Nature protection***



At least 7 live trees (among them at least 3 trees need to be older or having DBH larger than the average value for the whole stand) per 1 ha and 3 dead trees (DBH > 20 cm) per 1 ha shall be left in clear-cut areas over 1 ha. For clear-cut areas 0.5-1 ha, the figures are, respectively, 3 (2) and 2. Biodiversity trees are left in clear-cut areas for natural decay. Also stand level restrictions are introduced due to woodland key habitats, presence of nests of some birds.

### 5.8. Medium rotation shelter-wood/clear cuttings in coniferous forests MRCON\_CUS

The shelter-wood management model with group-occasional and group-selective final cutting could be considered as the most optimal in terms of silvicultural considerations. This model includes use of uniform and non-uniform shelter-wood and also clearcutting of smaller areas.

Nearly 10% of the CSA area is managed by this FMM aiming for mixed Norway spruce dominated stands to be cut by non-clear or clear cutting at maturity age.

Timber production is the primary ecosystem service.

Private forest ownership dominates (60%) in this FMM. Practically all edaphic conditions are represented. The main criteria to assign a Norway spruce dominating stand to this FMM was a significant presence of other tree species, such as birch, Scots pine, pedunculated oak, European aspen, grey and black alders in tree species composition; and availability of lower canopy layers.

Non-clear final cutting usually implies limited restrictions, while clear cutting, if applied, involves rather strong regulations regarding the size, dimensions and allocation of areas harvested at one time-point. The MARA for this FMM (71-81 years) is defined by legal acts.

In principle, natural regeneration should dominate in this FMM as both occasional and selective cuttings are aimed to facilitate natural regeneration and development of undergrowth. However, natural regeneration slightly dominates in private forests, while state forest managers' predominantly use artificial regeneration, including the non-clear cutting areas. Soil scarification is always done regenerating forests artificially, more, soil is also scarified to support the natural regeneration (~10% of cases). Even though forestry principles suggest intensive thinning; they are at the recommended levels only in state forests.

The nature protection integrated in the stand-level management is associated mostly with leaving some large and old trees when harvesting.

#### *Ecosystem services*

The most important ES is Timber production followed by fuel wood supply. Forest management shall also secure biodiversity protection and provision of environmental protection and recreational (Forest Cutting Rules) and carbon sequestration services.

#### *Tree species and mixtures*

Norway spruce is the dominant tree species but many other do occur; (share % of volume)

Norway spruce ( <i>Picea abies</i> )	69.0
Birch ( <i>Betula pendula</i> or <i>B. pubescens</i> )	12.6
Scots pine ( <i>Pinus sylvestris</i> )	8.9
Pedunculate oak ( <i>Quercus robur</i> )	3.6

European aspen ( <i>Populus tremula</i> )	3.5
Grey alder ( <i>Alnus incana</i> )	1.2
Black alder ( <i>Alnus glutinosa</i> )	0.8
Ash ( <i>Fraxinus excelsior</i> )	0.1
Goat willow ( <i>Salix caprea</i> )	0.1
Small-leaved lime ( <i>Tilia cordata</i> )	0.1
Norway maple ( <i>Acer platanoides</i> )	0.1

Also present larch (*Larix*), hornbeam (*Carpinus betulus*), *Salix*, *Ulmus minor*, other softwood deciduous species.

Tree species recommended to be used in addition to the Norway spruce are provided below according to the edaphic condition type for commercial forests, group IVA (based on Reforestation and afforestation rules):

Dry - medium: Scots pine, larch spp., Pedunculated oak, Norway maple, Small-leaved lime, European beech, Sessile oak (*Quercus petraea*), birch spp.

Mesic – medium: Scots pine, birch spp., Norway maple, Small-leaved lime, Pedunculated oak, European aspen, Black alder

Mesic – high: Birch spp., European ash, Pedunculated oak, Sessile oak (*Quercus petraea*), Black alder, Norway maple, Small-leaved lime, European aspen

On dry high productivity soils the following tree species should be targeted: Pedunculated oak, ash, Small-leaved lime, Norway maple, elm, Norway spruce, Sessile oak, birch, European aspen, Black alder.

### **Regeneration**

Artificial regeneration dominates in state forests (~90%) on the soils associated with this FMM, however, natural regeneration slightly dominates in private forests (54%).

Large diversity of cutting options could be applied in this FMM resulting also in diversity of regeneration options. Natural regeneration should dominate in this FMM. Both group-occasional and group-selective cuttings are aimed to facilitate natural regeneration and development of under-growth. The first type of non-uniform shelter-wood system aims for facilitating the natural regeneration in the whole stand, while the second one – only in the gaps. However, if the resulting natural regeneration is not sufficient, artificial regeneration is applied, e.g. the Forest Cutting Rules require artificial regeneration in gaps without sufficient amount of natural regeneration. If the clear cutting is used, then the regeneration should be artificial.

Following the algorithms of forest management planning incorporated into the Integrated IS of Forest Cadaster, natural regeneration is planned on 72% of state forests, previously dominated by Norway spruce and cut using non-clear cutting. ~50% of private forests harvested using the non-clear cutting were suggested for natural regeneration only.

### **Site preparation**



In state forests: soil scarification is always used for artificial regeneration. If natural regeneration is used, then soil is scarified on ~10% of the area. However, if there is a seed-rich year, soil scarification is used on ~30% of the area for natural regeneration. No confirmed facts about private forests, but most likely no soil scarification is used to facilitate the natural regeneration.

### ***Stand management***

State forests are thinned practically following the thinning standards, while private forests are significantly under-thinned, most likely due to avoiding extra costs and undervaluing the importance of pre-commercial thinning on the structure and growth of future stand.

The share of thinned stands in private forests tends to increase with the stand age – e.g. the relatively largest share of thinned stands belongs later part of the rotation period, when the output of commercially more valuable timber is higher.

### **Pre-commercial thinning**

Stand-wise forest inventory records indicate, that pre-commercial thinning was done on 1376 ha in state forests, making 49 % of the pre-commercial thinning age area and on 206 ha in private forests, making just 5% of the pre-commercial thinning age area.

All stands with Norway spruce and deciduous tree species shall be pre-commercially thinned at least once. The aim of pre-commercial thinning is to have a fully established mixed spruce stand with deciduous trees at an age of 20 years.

No matter the density, Norway spruce stands with 30-50% of deciduous trees, need to be thinned first at age ~7-10 years removing the deciduous trees which directly competing with spruce trees. Quite often the deciduous trees may come back and the pre-commercial thinning may need to be repeated for the 2nd time. However, if the natural regeneration is in tree-species groups, the pre-commercial thinning should aim to expand spruce groups. On mesic medium productivity soils groups of deciduous forests may be maintained on relatively lower and more wet places, without the spruce or where the wind damage risk is relatively higher.

### **Commercial thinning**

Stand-wise forest inventory records indicate, that the 1st commercial thinning was done on 937 ha in state forests, making 37% of the 1st commercial thinning age area and on 249 ha in private forests, making just 6% of the 1st commercial thinning age area. The 2nd commercial thinning was done on 445 ha in state forests, making 20% of the 2nd commercial thinning age area and on 599 ha in private forests, making 9% of the 2nd commercial thinning age area.

The 1st commercial thinning should reduce the amount of deciduous trees in the stand. However, the deciduous trees which are located in groups and do not disturb the spruce, do not need to be removed. Usually weak or so called “wolf” trees are removed; noble deciduous and pine, if present, need to be preserved. Groups of spruce are thinned to reach required number of stems per ha. The 2nd commercial thinning follow the same principles as the 1st commercial thinning, however, the thinning intensity should be less. Usually, the commercial thinning in spruce dominated stands should be repeated ~2 times.

### **Pruning**

Not relevant

### ***Harvest and logging residues***

There were some attempts to use harvesters for non-clear cutting, however, chain saws are preferred under shelter-wood cutting systems. If clear cutting in state forests is applied, then the harvester may be used.

Extraction of wood/timber is almost always (100%) done by forwarders, however, some private forest owners for own timber utilization may not use fully mechanized wood extraction. Telsiai SFE extracts using own equipment 85-90% (all FMMS).

Use of logging residues are not used (extracted).

### ***Nature protection***

This model for forest management aims for continuous cover forestry (up to some extent). The Forest felling rules also requires leaving not less than 3 trees per ha with the age over MARA and the diameter over the average value for the compartment.

### **5.9. Long rotation clearcutting in coniferous forest (pine) LRCON\_C**

Over 7% of the CSA area is managed by this FMM aiming for mainly Scots pine (over 80% of volume) dominated stands to be cut by clear cutting at maturity age. Around 40% of forests under this FMM belong to state.

This FMM includes the stands on wet soils, stands having relatively low density at pre-mature and mature age as well as pure pine stands.

The clear cutting is the harvesting method suggested by both economic and silvicultural reasoning, there are numerous restrictions regarding the size, dimensions and locating of cutting areas, see above. Timber production is the main ecosystem service. The stands are dominated by Scots pine, but there are often an admixture of Norway spruce and birch. The rotation period for this FMM (110-120 years) is defined by legal acts and is considered to be too long by forestry experts who analysed forest rotations during last 2 decades.

Artificial regeneration is prioritized no matter the ownership in this FMM with just ~10% of natural regeneration on wet soils. Soil scarification is done always if artificial regeneration is applied. The pre-commercial thinning should be applied at least once and the commercial thinnings – 2-3 times during the rotation. State forest managers are doing pre-commercial thinnings.

Nature protection integrated in the stand-level management is associated mostly with leaving some live and dead trees in clear-cut areas.

### ***Edaphic conditions***

The management model is used mainly on sites with lower production than average, from dry to wet sites, but it is also used on dry sites with medium production.

### *Ecosystem services*

The main ecosystem services from this model is timber production. Forest management shall also secure biodiversity protection and provision of environmental protection and recreation and carbon sequestration services.

### *Tree species and mixtures*

On sites managed with this model Scots pine mixed with some Norway spruce, birch, and larch should dominate. Only Scots pine and birch should be grown on wet low productivity soils. Dry medium productivity soils should be shared by Norway spruce, Scots pine, larch spp., Pedunculate oak, Norway maple, Small-leaved lime, European beech, Sessile oak (*Quercus petraea*), birch spp. On dry sites with low productivity Scots pine should grow in pure stands. Scots pine, Norway spruce and birch should be found on mesic low productivity soils.

Today many stands have an admixture of more than 25%, but it is suggested that majority of the area shall be managed as pure stands of Scots pine.

Tree species on all sites managed with clearcutting model with long rotation period for coniferous, % of volumes (no matter the main species):

Scots pine ( <i>Pinus sylvestris</i> )	80.4
Norway spruce ( <i>Picea abies</i> )	12.4
Birch ( <i>Betula pendula</i> or <i>B. pubescens</i> )	6.1
Larch ( <i>Larix</i> )	0.3
European aspen ( <i>Populus tremula</i> )	0.3
Pedunculate oak ( <i>Quercus robur</i> )	0.2
Black alder ( <i>Alnus glutinosa</i> )	0.1
Grey alder ( <i>Alnus incana</i> )	0.1

### **Regeneration**

Artificial regeneration, planting is most common, on approx. 10% of the area natural regeneration is done.

### **Site preparation**

Depends on the type of seedlings used. Usually soil is prepared, however, if planting material with closed root system is used and then the soil scarification is not applied.

### *Stand management*

#### **Pre-commercial thinning**

The thinning objective in pine dominated forests is to develop productive pine dominating forests. The pre-commercial thinning in pure pine stands should be started at age 15-20 years, thus, sometimes going beyond the pre-commercial thinning age. Of course, denser stands can be thinned at younger age. During the pre-commercial thinning special care shall be on minimizing snow damage



risks. Mixed pine-birch stands should be pre-commercially thinned already at age 5-8 years and thinning needs to be repeated if birch starts covering pine trees. European aspen needs to be always removed from pine stand. Large gaps in thinned mixed stands should be avoided. No thinning is applied in pine stands on wet low productivity soils.

Majority of pine stands need to be pre-commercially thinned 1-2 times. According to the records of stand-wise forest inventory, during the period 2006-2015 the pre-commercial thinning was done on 37% of the area, covered by stands of pre-commercial thinning age in state forests. The figure in private forests is 4%.

Based on data from stand-wise forest inventory the following pre-commercial thinning shares are proposed for 2016-2025: in state forests pre-commercial thinning is suggested on the area making 34% of the pre-commercial thinning age stand area. The figure for private forests is 38%.

Pre-commercial thinning in state forests seems to be done at the level corresponding to current silvicultural concepts. Private forests are under-thinned; the pre-commercial thinning seems to be avoided.

### **Commercial thinning**

The aim of commercial thinning in Lithuania is declared to be the development of optimal growing conditions for the most productive trees, removing damaged, low productivity trees. Mixed stands are maintained, however, reducing the share of deciduous trees. As the period for the 2nd commercial thinning is rather long (21-90 years), experts from SFIMPI suggest the 1st commercial thinning to be carried-out 1 time during the rotation and the 2nd commercial thinning – 1-2 times during the rotation (i.e. the commercial thinning should be carried-out 2 to 3 times during the rotation).

Based on data from stand-wise forest inventory the following commercial thinning shares are proposed for 2016-2025: in state forests the 1<sup>st</sup> commercial thinning is suggested on the area making 52% of the 1st commercial thinning age stand area (in private forests - 52%). The 2nd commercial thinning is suggested on the area making 21% of the 2nd commercial thinning age stand area (in private forests – 24%).

### **Pruning**

No pruning shall be done. However, there are some recommendations to have 2nd layer and under-growth under main Scots pine layer to facilitate natural removing low branches.

### **Harvest**

Near all state forests in this FMM are cut using harvesters. Chain saws dominate in private forests - harvesters are used in private forests less than 50% of cases.

Extraction of wood is fully mechanized as forwarders are used to almost 100%, however, some private forest owners for own timber utilization may not use fully mechanized wood extraction. Telsiai SFE extracts using own equipment 85-90% (all FMMS).

Logging residues are not extracted and used.



### *Nature protection*

At least 7 live trees (among them at least 3 trees need to be older or having DBH larger than the average value for the whole stand) per 1 ha and 3 dead trees (DBH > 20 cm) per 1 ha shall be left in clear-cut areas over 1 ha. For clear-cut areas 0.5-1 ha, the figures are, respectively, 3 (2) and 2. Biodiversity trees are left in clear-cut areas for natural decay. Also stand level restrictions are introduced due to woodland key habitats, presence of nests of some birds.

### 5.10. Long rotation uniform shelterwood or clearcutting in coniferous forest LRCON\_CUS

The model is focused on forestry in mixed Scots pine dominated stands, sometimes with the 2nd layer or undergrowth, where the non-clear felling is prioritized at maturity age due to silvicultural reasoning. Clear cutting is also possible.

Around 5.0% (only the area of forest stands is taken into account). 51% of the FMM area belongs to state. The area under this FMM should remain stable or decrease due to replacement with shorter rotation Norway spruce stands.

Timber production is the main ecosystem service.

The FMM is applied on dry-to-moist and medium and low productivity soils. There are practically 2 extra tree species in addition to Scots pine growing in this FMM – Norway spruce and birch, however in relatively larger shares than in other Scots pine stands.

When the non-clear cutting is applied there are no limitations regarding the area to be harvested at one-time point.

Natural regeneration should be prioritized where this is possible and should approach 100%. However, this is followed on private forests and most likely not due to silvicultural consideration. The share of naturally regenerated stands at pre-commercial thinning age was 69% in state forests. Soil scarification if natural regeneration is applied is used on ~10% of the area in state forests.

The pre-commercial thinning should be applied at least once and the commercial thinning – more than twice during the rotation. State forest managers are doing pre-commercial and the 1st commercial thinning following the silvicultural requirements, however private forests are significantly under-thinned.

Up to some extent this FMM aims for continuous cover forestry and the nature protection integrated in the stand-level management is associated mostly with leaving some large and old trees when harvesting.

### *Edaphic conditions*

This model is mainly used on low productive sites and some sites of medium productivity on dry and mesic soils.

### **Ecosystem services**

Timber production.

Forest management shall also secure biodiversity protection and provision of environmental protection and recreational (Forest Cutting Rules) and carbon sequestration services.

### ***Tree species and mixtures***

Scots pine with some Norway spruce, birch, larch should dominate. Dry medium productivity soils should be shared by Norway spruce, Scots pine, larch spp., Pedunculated oak, Norway maple, Small-leaved lime, European beech, Sessile oak (*Quercus petraea*), birch spp. Scots pine, Norway spruce and birch should be found on mesic low productivity soils.

Tree species share of volume volumes%

Scots pine ( <i>Pinus sylvestris</i> )	66.7
Norway spruce ( <i>Picea abies</i> )	24.4
Birch ( <i>Betula pendula</i> or <i>B. pubescens</i> )	7.8
European aspen ( <i>Populus tremula</i> )	0.7
Pedunculate oak ( <i>Quercus robur</i> )	0.3
Grey alder ( <i>Alnus incana</i> )	0.1
Black alder ( <i>Alnus glutinosa</i> )	0.1
Also present Goat willow ( <i>Salix caprea</i> ), Norway maple ( <i>Acer platanoides</i> )	

### ***Regeneration***

Natural regeneration should be prioritized where this is possible and should approach 100%.

State forestry still use rather significant part of artificial regeneration, while near all private forest stands under 20 years are naturally regenerated in this FMM.

### **Site preparation**

Depends on the regeneration type. Soil should be prepared for artificial regeneration. However, if natural regeneration is applied, then soil scarification should be used in some area to facilitate the regeneration. In state forests soil scarification is always used for artificial regeneration. If natural regeneration is used, then soil is scarified on ~10% of the area. No confirmed facts about private forests, but most likely no soil scarification is used to facilitate the natural regeneration.

### ***Stand management***

The thinning objective in pine dominated forests is to develop productive pine dominating forests.

### **Pre-commercial thinning**

During the pre-commercial thinning special care shall be on minimizing snow damage risks. Mixed pine-birch stands should be pre-commercially thinned already at age 5-8 years and thinning needs to be repeated if birch starts covering pine trees. European aspen needs always to be removed from pine stand. Large gaps in thinned mixed stands should be avoided. No thinning is applied in pine stands on wet low productivity soils. Majority of pine stands need to be pre-commercially thinned at least 1 time.

Pre-commercial thinning in state forests seems to be done at the level corresponding to current silvicultural concepts. Private forests are under-thinned; the pre-commercial thinning seems to be avoided. Reasons are cost, not caring, not considering pre-commercial thinning as important.

### **Commercial thinning**

The aim of commercial thinning in Lithuania is declared to be the development of optimal growing conditions for the most productive trees, removing damaged, low productivity trees with bad stem form.

Mixed stands are maintained, however, reducing the share of deciduous trees. As the period for the 2nd commercial thinning is rather long (21-90 years), experts from SFIMPI suggest the 1st commercial thing to be carried out 1 time during the rotation and another 1-2 thinnings during the rotation (i.e. the commercial thinning should be carried-out 2 to 3 times during the rotation).

### **Pruning**

No pruning is done.

### **Harvest**

There were some attempts to use harvesters for non-clear cutting, however, chain saws are preferred under shelter-wood cutting systems. If clear cutting in state forests is applied, then the harvester may be used.

Almost all extraction of timber/wood is done by forwarder, however, some private forest owners for own timber utilization may not use fully mechanized wood extraction. Telsiai SFE extracts using own equipment 85-90% (all FMMS).

Logging residues are not extracted or used.

### **Nature protection**

FMM aims for continuous cover forestry (up to some extent). The Forest felling rules also requires leaving not less than 3 trees per ha with the age over MARA and the diameter over the average value for the compartment.

#### **5.11. Medium rotation non-uniform shelter-wood in coniferous forests MRCON\_NUS**

This FMM is associated with using non-clear cutting in pure and mixed Norway spruce dominated forests due legal requirements (i.e. no clear cutting requirement in National Parks, along major roads and around reserves). Forestry professionals consider that such requirements sometimes contradict professional forestry concepts, even leading to degradation of Norway spruce stands.

Nearly 4% of the CSA area is managed by this FMM, the shares of state and private forests are nearly equal. The area should remain at the same level as covered today if there are no changes in forestry legislation and the system of protected areas.

Timber production is the primary ecosystem service.

Practically all edaphic conditions are represented here, except some wet soil types. The non-uniform shelter-wood FM system with group-occasional and group-selective final cutting could be considered as the most optimal in terms of silvicultural considerations here. Non-clear final cutting usually implies limited restrictions, regarding the size, dimensions and allocation of areas harvested at one time-point. The lowest age for final felling (71-91 years) is defined by legal acts and is considered to be too long by some forestry experts. The rotation period in state forests is even longer due to the principles of estimation of annual cutting norm, which are not applied for private forests.

Around 1/3 of stands in this FMM are naturally regenerated both in state and private forests. Notably, this is practically the only FMM in the CSA with near equal shares of artificial regeneration in state and private forests. In state forests, soil scarification is always done if regenerating forests artificially. Soil is also scarified to support the natural regeneration (~10 to 30% of the area to be regenerated, depending on seed-productivity).

Pre-commercial and commercial thinning in state forests are at appropriate level, while the private forests are practically neither pre-commercially nor commercially thinned.

The nature protection integrated in the stand-level management is associated mostly with leaving some large and old trees when harvesting. The non-clear cutting requirement is an important measure itself, too.

The forest management principles in this model are predefined by the location of forests – i.e. they involve clear cutting restrictions in National parks, around the reserves and along major roads, sometimes contradicting with the forestry practice in Lithuania. The common opinion of professional foresters is that the Norway spruce stands are best re-established using clear cut system followed by artificial regeneration. According to current legal acts there should be no changes in the share of current FMM. However, alternative FMM could involve combining this FMM with clear-cut or shelter-wood FMM in medium rotation coniferous forests.

### **Edaphic conditions**

This management model is mainly found on medium productive sites on dry soil. The model should be avoided on wet soils due to silvicultural considerations. 0.5% of the area was found basically around the reserves.

### **Ecosystem services**

Timber production and second Fuel wood supply. However, the importance of other ESs is higher than in other Norway spruce dominated stands of the CSA. Forest management shall also secure biodiversity protection and provision of environmental protection and recreational (Forest Cutting Rules) and carbon sequestration services.

### **Tree species and mixtures**

Norway spruce shall dominate, with birch, Scots pine, pedunculated oak, European aspen, and black alder making slightly larger share. The tree species to be used in addition to the Norway spruce are provided below according to the edaphic condition type for commercial forests.

Dry – medium fertility: Scots pine, larch spp., Pedunculated oak (*Quercus robur*), Norway maple, Small-leaved lime, European beech, Sessile oak (*Quercus petraea*), birch spp.

Mesic – medium fertility: Scots pine, birch spp., Norway maple, small-leaved lime, pedunculated oak, European aspen, black alder.

Mesic – high fertility: Birch spp., European ash, Pedunculated oak, Sessile oak (*Quercus petraea*), Black alder, Norway maple, Small-leaved lime, European aspen.

On dry high productivity soils the following tree species should be targeted: Pedunculated oak, ash, Small-leaved lime, Norway maple, elm, Norway spruce, Sessile oak, birch, European aspen, Black alder.

In the Norway spruce prevailing stands other tree species share the following volumes:

Norway spruce ( <i>Picea abies</i> )	0.4
Scots pine ( <i>Pinus sylvestris</i> )	7.9
Birch ( <i>Betula</i> – <i>B. pendula</i> or <i>B. pubescens</i> )	5.8
Pedunculate oak ( <i>Quercus robur</i> )	3.7
European aspen ( <i>Populus tremula</i> )	1.2
Grey alder ( <i>Alnus incana</i> )	0.4
Black alder ( <i>Alnus glutinosa</i> )	0.2
Ash ( <i>Fraxinus excelsior</i> )	0.1
Goat willow ( <i>Salix caprea</i> )	0.1
Small-leaved lime ( <i>Tilia cordata</i> )	0.1
Norway maple ( <i>Acer platanoides</i> )	0.1
Also present larch ( <i>Larix</i> ), hornbeam ( <i>Carpinus betulus</i> )	

### Regeneration

According to the records from stand-wise forest inventory, the share of natural regeneration was during the last decade 33% in state forests and 28% in private forests.

The non-clear cutting requirement is usually associated with the increased importance of natural regeneration. However, in this FMM, the non-clear cutting requirement is due to the requirements of legal acts and the geographic location of forests. So, due to natural conditions, special purpose of the forests and importance of recreational and aesthetic values, the natural regeneration should not dominate.

According to the data of stand-wise forest inventory, natural regeneration is suggested for 31% of state forests (18% in private forests).

### Site preparation

Depends on the regeneration type. Soil should be prepared for artificial regeneration. However, if natural regeneration is applied, then soil scarification should be used in some area to facilitate the regeneration, including the scarification in gaps.

Soil scarification is always used for artificial regeneration in State forest. If natural regeneration is used, then soil is scarified on ~10% of the area. However, if there is a seed-rich year, soil scarification is used on ~30% of the area for natural regeneration. No confirmed facts about private forests, but most likely no soil scarification is used to facilitate the natural regeneration.

## **Stand management**

### **Pre-commercial thinning**

The pre-commercial thinning (based on data from stand-wise forest inventory from 2015 and using the functionality of integrated forest cadaster IS) should be carried-out on 52% of the area covered by forests of pre-commercial thinning age in state forests during 2016-2025. The share of planned pre-commercial thinning during the coming decade in private forests is 50%.

Thus, the share of the area where this FMM is applied should be pre-commercially thinned at least once during a rotation period is 100%.

Stand-wise forest inventory records indicate, that pre-commercial thinning was done during 2006-2015 on 135 ha in state forests, making 50 % of the pre-commercial thinning age area and on 3,4 ha in private forests, making just 3% of the pre-commercial thinning age area. Note: some omission errors may be present in the database.

### **Commercial thinning**

The 1st commercial thinning (based on data from stand-wise forest inventory from 2015 and using the functionality of integrated forest cadaster IS) should be carried-out on 29% of the area covered by forests of the 1st commercial thinning age in state forests during 2016-2025. The share of planned 1st commercial thinning during the coming decade in private forests is 75%. The figures for the 2nd commercial thinning are, respectively, 22% and 55%. The relatively larger share of stands requiring the commercial thinning in private forests is likely resulted by larger stand densities due to under-thinning.

Stand-wise forest inventory records indicate, that the 1st commercial thinning was done during 2006-2015 on 100 ha in state forests, making 33% of the 1st commercial thinning age area and on 7 ha in private forests, making just 2% of the 1st commercial thinning age area. The 2nd commercial thinning was done on 29 ha in state forests, making 15% of the 2nd commercial thinning age area and on 39 ha in private forests, making 11% of the 2nd commercial thinning age area.

### **Pruning**

No pruning is done in this FMM

### **Harvest**

Chain saws are preferred under shelter-wood cutting systems.

Extraction of wood are mostly mechanized, however, some private forest owners for own timber utilization may not use fully mechanized wood extraction.

Logging residues are not extracted and used.

### **Nature protection**

This model for managing forest aims for continuous cover forestry (up to some extent). The Forest cutting rules also require leaving not less than 3 trees per ha with the age over MARA and the diameter over the average value for the compartment. The non-clear cutting requirement is an important measure itself, too.

#### **5.12. Long rotation uniform shelter-wood in coniferous forests LRCON\_US**

This FMM is associated with using non-clear cutting in pure and mixed Scots pine dominated forests due legal requirements (i.e. no clear cutting in National Parks, along major roads and around reserves) and political will of forestry administration to increase the share of non-clear cutting (here – applying so called Labanauskas cutting, when the stand is cut in two occasions, leaving ~80-100 pine trees per ha after the first cutting intervention and expecting for natural regeneration). Timber production is the main ecosystem service.

Around 3% of the CSA area is managed by this FMM, the shares of state and private forests are near equal. This model for managing forest is very important at the country level, thus it was included even though the share at CSA level is relatively low. The shares of state and private forests in this FMM are practically equal (47:53%).

The FMM is applied practically on all edaphic conditions where the Scots pine may be met. There are practically 2 extra tree species in addition to Scots pine growing in this FMM. The rotation period for this FMM (110-120 years) is defined by legal acts and is considered to be too long by some forestry experts. The rotation period in state forests is even longer due to the principles of estimation of annual cutting norm, which are not applied for private forests, yielding in relatively large areas of over-mature forests and high average age.

There are no limitations regarding the area to be harvested at one-time point, except the Labanauskas cutting, where the simplified clear-cutting limitations for the cutting area dimensions, allocation and cutting repetition frequencies apply.

Even the natural regeneration should be prioritized under this FMM, local conditions require artificial regeneration to dominate, especially in state forests. Soil scarification if natural regeneration is applied is used on near 100% of the area in state forests.

The pre-commercial thinning should be applied at least once and the commercial thinning – more than twice during the rotation. State forest managers are doing pre-commercial and the 1st commercial thinning following the silvicultural requirements, however private forests are significantly under-thinned.

Up to some extent this FMM aims for continuous cover forestry and the nature protection integrated in the stand-level management is associated mostly with leaving some large and old trees when harvesting.

### ***Edaphic conditions***

This FMM is mainly used on dry sites with medium and low production. It should be avoided on wet soils due to silvicultural considerations.



### ***Ecosystem services***

Timber production is the main ES with this FMM.

Forest management shall also secure biodiversity protection and provision of environmental protection and recreational (Forest Cutting Rules) and carbon sequestration services.

### ***Tree species and mixtures***

The main tree species are Scots pine (*Pinus sylvestris*) but also some larch stands can be found.

Tree species share the following volumes (%):

Scots pine ( <i>Pinus sylvestris</i> )	84.6
Norway spruce ( <i>Picea abies</i> )	11.7
Birch ( <i>B. pendula</i> or <i>B. pubescens</i> )	3.1
Pedunculate oak ( <i>Quercus robur</i> )	0.3
European aspen ( <i>Populus tremula</i> )	0.1
Grey alder ( <i>Alnus incana</i> )	0.1

Also present Small-leaved lime (*Tilia cordata*), Black alder (*Alnus glutinosa*), Goat willow (*Salix caprea*), Norway maple (*Acer platanoides*), *Populus*, larch (*Larix*), hornbeam (*Carpinus betulus*).

### ***Regeneration***

In principle, the objective should be to have natural regeneration on 100% of the FMM area. However, based on regeneration proposals of integrated forest cadaster IS, around 50% of areas with clear cutting restrictions in state forests (basically in Zemaitija NP) should be naturally regenerated. The figure for private forests is 46%. Artificial regeneration is prioritized (~90%) on dry low productivity soils.

But in reality, the share of naturally regenerated stands at pre-commercial thinning age was 10% in state and 38% in private forests.

State forest managers prefer artificial regeneration. The share of naturally regenerated forest in state forests could be larger. It seems, that the state forest managers prefer having higher regeneration quality using artificial regeneration. Natural regeneration, especially if Labanauskas cutting method is used, is very poor in the CSA. For that reason, they plant artificially a lot.

### **Site preparation**

With Labanauskas cutting method scarification is always done. The scarification should be less intensive with decreasing soil productivity. Soil scarification should be combined with the seed yield years. Soil scarification sometimes is not welcome in Zemaitija National Park.

### ***Stand management***

The thinning objective in pine-dominated forests is to develop productive pine-dominated forests.

### **Pre-commercial thinning**





During the pre-commercial thinning special care shall be taken to minimize snow damage risks. Mixed pine-birch stands should be pre-commercially thinned already at age 5-8 years and thinning needs to be repeated if birch starts covering pine trees. European aspen needs to be always removed from pine stand. Large gaps in thinned mixed stands should be avoided. No thinning is applied in pine stands on wet low productivity soils. So, majority of pine stands need to be pre-commercially thinned at least one time.

Based on data from stand-wise forest inventory the following pre-commercial thinning shares are proposed for 2016-2025: in state forests pre-commercial thinning is suggested on the area making 47% of the pre-commercial thinning age stand area. The figure for private forests is 48%.

According to the records of stand-wise forest inventory, during the period 2006-2015 the pre-commercial thinning was done on 42% of the area, covered by stands of pre-commercial thinning age in state forests. The figure in private forests is 2%.

Pre-commercial thinning in state forests seems to be done at the level corresponding to current silviculture concepts. Private forests are under-thinned; the pre-commercial thinning seems to be avoided. Reasons: cost saving, not caring, not considering pre-commercial thinning as important under this FMM, avoiding additional forestry activities in protected areas.

### **Commercial thinning**

The aim of commercial thinning in Lithuania is declared to be the development of optimal growing conditions for the most productive trees, removing damaged, low productivity trees. Mixed stands are maintained, however, reducing the share of deciduous trees. As the period for the 2nd commercial thinning is rather long (21-90 years), experts from SFIMPI suggest the 1st commercial thing to be carried-out 1 time during the rotation and the 2nd thinning – 1-2 times during the rotation (i.e. the commercial thinning should be carried-out 2 to 3 times during the rotation).

The 2nd commercial thinning seems to be under assumed optimal level both in state and private forests. It should be noted, that the share of the 2nd commercial thinning in private forests is larger than for thinning in younger stands, possible due to the availability of more valuable timber assortments. The 1<sup>st</sup> commercial thinning is approximately at the expected level in state forests and under that level in private forests.

### **Pruning**

No pruning.

### **Harvest**

There were some attempts to use harvesters for non-clear cutting, however, chain saws are preferred under shelterwood cutting systems. If clear cutting in state forests is applied, then the harvester may be used. Extraction of wood/timber is 100% mechanized.

The logging residues are usually not extracted in state forests.

### **Nature protection**



The management model aims for continuous cover forestry (up to some extent). The Forest felling rules also requires leaving not less than 3 trees per ha with the age over MARA and the diameter over the average value for the compartment. The non-clear cutting requirement is an important measure itself, too.

### 5.13. Medium rotation uniform shelterwood clearcutting in deciduous forest MRDEC\_US

This FMM is applied on birch (much less Black alder and Small-leaved lime) dominated mixed stands with the diversity of other tree species on dry to moist medium productivity soils.

The FMM belongs to the uniform shelter-wood management system, however, group selection cutting of non-uniform shelter-wood system may also be applied. Clear felling and artificial regeneration may be applied here; however, they are rare

Nearly 13% of the CSA area is managed by this FMM and the private forest ownership dominates here (77%).

As the timber production is the main ecosystem service, the FMM is focused on converting trivial deciduous dominating stands into more profitable mixed Norway spruce and deciduous stands. The rotation length is the same as for clear felling and is considered to be too long.

There are practically no limitations for the characteristics of area to be harvested at one-time point. The distinctive feature is that this FMM is dealing with mixed forests with the most abundant tree species on the stand being around 50-74% and this diversity should be maintained, however, trying to care for Norway spruce and remove low value species like Grey alder and Goat willow.

According to silvicultural recommendations, the pre-commercial and commercial should be applied at least several times during a rotation, especially where is the need to take care for Norway spruce. The pre-commercial and the 1st commercial thinning are done in practice in nearly required amount in state owned forest. The 2nd commercial thinning seems to be rare in all forests no matter the ownership.

Nature protection integrated in the stand-level management is associated mostly with leaving some old and large trees when harvesting.

#### *Edaphic conditions*

This FMM will be continued on medium productivity soils. It is very unlikely the non-clear felling to be effective on highly productive soils, unless there are groups of coniferous trees to apply group-selective cutting. Low productivity soils should be associated with other FMMs.

#### *Ecosystem services*

Timber production.

Fuel wood supply.

Forest management shall also secure biodiversity protection and provision of environmental protection and recreational (Forest Felling Rules) and carbon sequestration services.

#### *Tree species and mixtures*



This FMM is associated first of all with mixed birch and Norway spruce stands and aiming to get mixed Norway spruce – birch stands. So, the most abundant tree species on the stand will always be around 50-74%.

Tree species share the following volumes (no matter the main species):

Birch (B. pendula or B. pubescens)	58.2
Norway spruce (Picea abies)	11.4
European aspen (Populus tremula)	9.9
Black alder (Alnus glutinosa)	7.6
Grey alder (Alnus incana)	6.2
Scots pine (Pinus sylvestris)	2.8
Pedunculate oak (Quercus robur)	2.0
Goat willow (Salix caprea)	0.7
Small-leaved lime (Tilia cordata)	0.6
Ash (Fraxinus excelsior)	0.3
Norway maple (Acer platanoides)	0.2
Hornbeam (Carpinus betulus)	0.1

Also present willow (*Salix*), elm (*Ulmus glabra*), European white-elm (*Ulmus laevis*), Field elm (*Ulmus minor*), other deciduous tree species.

### **Regeneration**

This method is associated with natural regeneration, only if clear felling is applied artificial regeneration shall be used. Artificial regeneration during the last decade was ~ 2% in forests which could be associated with this FMM according to the characteristics of previous stand.

### **Site preparation**

No scarification should be needed or used.

### **Stand management**

#### **Pre-commercial thinning**

There should be no pre-commercial thinning applied if the pure deciduous stands are under focus. However, if the aim is to develop Norway spruce dominating stand, then the pre-commercial thinning should be applied at least once. The internal forest management plan for Telsiai SFE suggests pre-commercial thinning on 40% of birch dominated stands (this partly overlaps with the FMM involving clear final felling on medium rotation deciduous forests).

All pole stage birch dominated stands (under 20 years) were thinned during the last decade on 40% of the area in state forests and only on 2.5% in private forests (data from stand-wise forest inventory, private forest data may contain some omission errors). As some of alder stands could be thinned more than a decade ago, the share of the area where this FMM is applied is pre-commercially thinned at least once during a rotation period could be guessed to be 60-80% in the state forests and much under 10% in private forests.

Pre-commercial thinning seems to be applied following the required amounts in state forests but is practically abandoned in private forests, most likely due to considering naturally regenerated deciduous stands as not requiring additional care and no interest for developing spruce stands.

### **Commercial thinning**

According to the opinion of forest management planning experts from FIFMPI, there should be the 1st and the 2nd pre-commercial thinning applied at least once each, i.e. yielding in 2 commercial thinnings for medium rotation deciduous forests. However, the state forest managers do not support this approach suggesting less commercial thinning. So, our expert judgement is that on average medium rotation deciduous forests should be commercially thinned on average 1.5 times.

Based on the data from stand-wise forest inventory, the 1st commercial thinning is suggested on 43% of the area in birch dominated stands in state forests (40% in private forests), the 2nd commercial thinning is suggested on 57% of the area in birch dominated stands in state forests (59% in private forests).

Commercial thinning in birch dominated stands assumed to be cut at maturity age using non-clear cutting seem to be under suggested level. Especially the 2nd commercial thinning seems to be avoid-ed. This is also much to the fact, that the 2nd thinning is applied when stands are of 41-50 years of age, i.e. just one decade younger than the MARA.

No pruning is done in this FMM.

### **Harvest**

No harvesters are applied in non-clearcutting. Extraction is fully mechanized. Logging residues are not extracted

### **Nature protection**

FMM aims for continuous cover forestry (up to some extent). The Forest felling rules also requires leaving not less than 3 trees per ha with the age over MARA and the diameter over the average value for the compartment.

#### **5.14. Medium rotation clear cutting in deciduous (birch and black alder) forests MRDEC\_C**

Today 10,2 % of the area is managed with this model for clearcutting mainly birch but also black alder. This FMM is the main competitor to medium rotation clear cutting in coniferous (Norway spruce) forests on dry and mesic medium productivity edaphic conditions. Spruce dominated stands yield which 1.7-2 time more than birch (or alder). However, potential market for birch timber should be taken into account as well as lower costs for afforestation (due to larger share of natural regeneration) and thinning (due to less thinning). In any case, this model should keep its importance on wet edaphic conditions making ~50% of the area managed by this FMM. So, the share of the forest area should be 5-10%. The share of the forest area in the CSA covered by this FMM could be less but no lower than 5%, because this is a FMM competing with medium rotation management approach ending with clear cutting in Norway spruce stands. After being cut, current forests on wet soils (basically black alder stands) should be left for natural regeneration resulting in continuation of this FMM.

Notably, >2/3 of the area under this FMM are privately owned, thus silvicultural treatments requiring professionalism or costs, would be rather doubtful

The rotation periods and the sizes and distribution of final cutting areas are strongly regulated by the Forest cutting rules. The rotation periods are suggested to be shorted by many experts. Although the rotation period is the same for all main tree species under this FMM (Black alder and birch spp.), regeneration principles and implementation of thinnings are somewhat different for birch (72% of FMM area) and alder (27%) dominated stands.

On mesic and dry medium productivity soils this FMM “competes” with growing Norway spruce dominated stands, however there are no “competitors” for Black alder stands on wet and some moist soils. Although this FMM is dealing with mixed forests with the most abundant tree species on the stand being around 50-94% of standing volume and this diversity should be maintained, some pure stands may also be naturally regenerated, especially on wet soils. High diversity of tree species is suggested for artificial regeneration, however the share of Black alder should be increased. Most of current Black alder stands should be recovered using natural regeneration (except the stands on drained soils). Around 50% of birch stands, belonging to the 1st selection group should also be naturally regenerated. However, artificial regeneration is more commonly used than it should be in state forests, while private forest owners prioritize natural regeneration even in the areas where it should not be used.

Usually more thinnings are required in birch dominated than in Black alder dominated stands. Pre-commercial thinning is usually not suggested only in pure stands, however, it is practically completely avoided by private forest owners. State foresters apply pre-commercial thinning in optimal amounts. Although interviewed experts recommend that stands should be commercially thinned on average 1.5 time, the actual implementation is less than 1 time. One of the reasons why the 2nd commercial thinning is much under suggested amounts is the unwillingness to interrupt with in-intermediate cutting not long before the final cutting is done.

Nature protection integrated in the stand-level management is associated mostly with leaving some live and dead trees in clear-cut areas.

### ***Edaphic conditions***

This FMM should be continued on moist and wet soils, however forestry on dry and mesic soils should aim to replace birch and black alder with spruce. However, medium rotation deciduous forests may hardly be fully replaced by spruce-dominated stands on dry and mesic medium productivity soils, thus we assume there will always be some birch and black alder-dominated stands pre-sent there. High productivity dry and mesic soils should be reserved for more valuable tree species.

### ***Ecosystem services***

Timber production and second fuel wood supply.

Forest management shall also secure biodiversity protection and provision of environment protection and recreational services (Forest Cutting Rules) and carbon sequestration.

### ***Tree species and mixtures***



The tree species to be used are provided below according to the edaphic condition type for commercial forests. Pure stands usually are birch stands (sometimes with Norway spruce in the 2nd layer). Pure black alder stands dominate on wet and moist soils.

Wet and highly productive – Black alder, ash, birch spp., Norway spruce.

Wet and medium productivity – Black alder, birch spp., Scots pine, Norway spruce.

Mesic and medium productivity – Norway spruce, Scots pine, birch spp., Norway maple, Small-leaved lime, pedunculated oak, European aspen and Black alder.

Dry and medium productivity – Norway spruce, Scots pine, larch spp., Pedunculated oak, Norway maple, Small-leaved lime, European beech, Sessile oak (*Quercus petraea*), birch spp.

Dry and mesic highly productive sites currently under this FMM, should be reforested by pedunculated oak, ash, Small-leaved lime, Norway maple, Elm, Norway spruce, Sessile oak, birch spp., European aspen and Black alder

In general, the share of Black alder should increase (Telsiai SFE).

Today the tree species share (%) of standing volumes (no matter the main species):

Birch ( <i>Betula pendula</i> or <i>B pubescens</i> )	61.0
Black alder ( <i>Alnus glutinosa</i> )	23.8
Norway spruce ( <i>Picea abies</i> )	6.1
European aspen ( <i>Populus tremula</i> )	2.8
Grey alder ( <i>Alnus incana</i> )	2.7
Scots pine ( <i>Pinus sylvestris</i> )	1.8
Pedunculate oak ( <i>Quercus robur</i> )	0.7
Ash ( <i>Fraxinus excelsior</i> )	0.3
Small-leaved lime ( <i>Tilia cordata</i> )	0.3
Goat willow ( <i>Salix caprea</i> )	0.1
Norway maple ( <i>Acer platanoides</i> )	0.1

Also present willow (*Salix*), hornbeam (*Carpinus betulus*), larch (*Larix*), elm (*Ulmus glabra*), European white-elm (*Ulmus laevis*), poplar (*Populus*).

The share of Black alder should increase, as should increase the share of Norway spruce. The share of birch should go down as this FMM should be replaced with medium rotation coniferous forest management ending with clear cut where it is possible.

### **Regeneration**

During last decade the clear-cut areas were re-established using natural regeneration as follows:

Former birch stands – 31% in state forests and 70% in private forests, and former Black alder stands – 65% in state forests and 98% in private forests

Around 10% of clear cut areas in private forests were not regenerated more than 4 years after being cut.

Natural regeneration is used in birch stands belonging to the 1st selection group – currently ~50% of birch stands belong to this group. Thus, assuming the shares of birch and Black alder – around 60% of the trees reaching the pole stage should be established through natural regeneration. 70-80% of current Black alder stands should be left for natural regeneration. The exception is Black alder stands on drained soils with lowered water-table – there is practically no natural Black alder regeneration in the CSA on dry turf.

Natural regeneration is under the expected level in state forests, even though the opinion of reforestation experts from Telsiai SFE supports larger shares of natural regeneration, they seem to be preferring artificial regeneration. Vice-versa, natural regeneration exceeds the optimal level in private forests (the share of 1st selection group birch stands in private forests is 54% as well as the share of drained Black alder stands is 27%), most likely due to avoidance of costs for artificial regeneration.

### **Site preparation**

Soil scarification shall be done if artificial regeneration is applied. No need for scarification if natural regeneration is applied. However, sometimes soil conditions may not be improved by scarification in this FMM... Planting has always been associated with soil preparation in advance. If container seedlings are used, the soil preparation may not be mandatory needed.

With artificial regeneration soil preparation is always done on state forests land. No information available on soil preparation in private forests. Most likely, some private forest owners, especially if using services of third parties, apply the soil preparation.

### ***Stand management***

#### **Pre-commercial thinning**

According to the data from stand-wise forest inventory, 11-20 years old stands in state forests have record of pre-commercial thinning on 30% of the area (i.e. they have been thinned in the period 2006-2015). In private forests, only 3% of the area have thinning record. Thus, the area where pre-commercial thinning is applied at least once during the rotation period is much below 100% in private forests and around 100% or below in state forests.

There should be no pre-commercial thinning applied if the pure deciduous stands are under focus (there are over 7% of such stands in this FMM which have reached the pole stage). However, if the aim is to develop Norway spruce dominating stand, then the pre-commercial thinning should be applied at least once. The internal forest management plan for Telsiai SFE suggests pre-commercial thinning on 40% of birch-dominated stands and on 20% of Black alder-dominated stands (this partly overlaps with the FMM involving non-clear final cutting on medium rotation deciduous forests).

Pre-commercial thinning seems to be used applied following current silvicultural concepts in state forests. However, pre-commercial thinning in private forests is practically avoided. This could be explained, in addition to saving costs, that private forest owners, majority of which are “household” or “ad-hoc” foresters in the CSA (Stanislovaitis et al., 2015), are lacking professional forestry knowledge and skills, or sharing concept that “there is no intervention need in young deciduous dominated forests at all”.



### **Commercial thinning**

According to the data from stand-wise forest inventory, the commercial thinning was done and is recorded during the period 2006-2015 on 25% of the area managed by this FMM and having age 25-44 years in state owned forests (2% in private forests). The commercial thinning in state owned stands over 44 years old but below the thinning age limit was applied and recorded during the last decade on 9% of the area (3% in private forests). Thus, the area where commercial thinning is applied at least once during the rotation period is below 100%.

It is often recommended that there should be the two commercial thinnings a yielding in medium rotation deciduous forests. However, the state forest managers do not support this approach suggesting less commercial thinning. So, our expert judgement in that on average medium rotation deciduous forests should be commercially thinned on average 1.5 times.

Based on the data from stand-wise forest inventory, the 1st commercial thinning is suggested on 43% of the area in birch dominated stands in state forests (40% in private forests), the 2nd commercial thinning is suggested on 57% of the area in birch dominated stands in state forests (59% in private forests).

In Black alder dominated stands: state forests, the 1st commercial thinning – 17% and the 2nd commercial thinning – 78%; private forests, the 1st commercial thinning – 3% and the 2nd commercial thinning – 53%.

### **Pruning**

Pruning is not done in this FMM.

### **Harvest**

Around 70% of harvesting is done using harvesters in state owned forests. Harvesters are used in private forests less than 50% of cases. Chain saws are used basically by harvesting contractors in areas with more unfavourable conditions for harvester or in private forests.

Extraction of wood and timber is fully mechanized on state forest, but some private forest owners for own timber utilization may not use fully mechanized wood extraction. Logging residues are not extracted and used.

### **Nature protection**

At least 7 live trees (among them at least 3 trees need to be older or having DBH larger than the average value for the whole stand) per 1 ha and 3 dead trees (DBH > 20 cm) per 1 ha shall be left in clear-cut areas over 1 ha. For clear-cut areas 0.5-1 ha, the figures are, respectively, 3 (2) and 2. Biodiversity-typic trees are left in clear-cut areas for natural decay. Also stand level restrictions are introduced due to woodland key habitats, presence of nests of some birds.

### **5.15. Short rotation uniform shelter-wood/clear cutting in deciduous forests SRDEC\_CUS**

About ~7.5% of the CSA area is managed by this FMM. This is one of few FMMs with clear dominance of private forest owners (90%). Following the Lithuanian forestry concepts, the area



under this FMM could be related to the cases of “unsuccessful” forestry, as mixed Grey alder and European aspen stands occupy the most productive soils here.

Although the main ES is assumed to be fuelwood supply, there is some potential for timber supply, especially focusing on specific assortments, too.

The FMM resembles most the uniform shelter-wood management system due to silvicultural considerations, however clear cutting and non-uniform shelter-wood systems may also apply. If non-clear occasional cutting is applied, there are no limitations for this FMM regarding the area to be harvested at one-time point.

The rotation period for private forest owners is not regulated. The final cutting methods chosen for this FMM are focused on taking care for more commercially valuable tree species, which are expected to replace grey alder or European aspen or decrease their abundance. However, the management that is applied does not indicate any chances for reaching formal forestry objectives.

Only natural regeneration is used in this FMM. Even some pre-commercial and 1st commercial thinning is proposed following silvicultural recommendations, the thinning in fact is done only on several compartments.

Nature protection integrated in the stand-level management is associated mostly with leaving some old and large trees when harvesting.

#### ***Edaphic conditions***

This model is mainly used on high productive sites. Following the Lithuanian forestry principles, the high productivity soils should not be used for low commercial value tree species as grey alder and should be transferred to other FMMs. Mixed forests belong to this FMM, usually containing more commercially valuable tree species in tree species composition and significant amount of undergrowth, i.e. the reason for separating such forests from the FMM with short rotation deciduous clear cutting has been the expectations for better use of soil potential (in commercial terms).

#### ***Ecosystem services***

Fuelwood production.

Forest management shall also secure biodiversity protection and provision of environmental protection and recreational (Forest Cutting Rules) and carbon sequestration services. Timber supply in some cases.

#### **Tree species and mixtures**

Mixed stands on productive soils are managed in this FMM. Usually there is significant amount of undergrowth or 2nd layer, which is distributed evenly in the area, suggesting simplified occasional cutting. However, if the undergrowth is distributed in groups or there is relatively significant share of Norway spruce (>30%) in tree species composition, group-occasional cuttings (system C) may also be applied. Clear cutting is also possible.

Based on Re-forestation and afforestation rules, the following tree species should be present on soils, occupied by forests belonging to current FMM:

- On dry sites with high productivity soils the following tree species should be targeted: Pedunculated oak, ash, Norway spruce, Small-leaved lime, Norway maple, elm, Norway spruce, Sessile oak, birch, European aspen and black alder.

- Dry sites with medium productivity: Norway spruce, Scots pine, larch spp., Pedunculated oak, Norway maple, Small-leaved lime, European beech, Sessile oak (*Quercus petraea*), birch spp.

- Mesic with high productivity: Norway spruce, birch spp., European ash, Pedunculated oak, Sessile oak (*Quercus petraea*), Black alder, Norway maple, Small-leaved lime, European aspen

Mesic with medium productivity: Norway spruce, Scots pine, birch spp., Norway maple, Small-leaved lime, pedunculated oak, European aspen, Black alder

**Tree species share the following volumes (no matter the main species):**

Grey alder ( <i>Alnus incana</i> )	41.6%
European aspen ( <i>Populus tremula</i> )	28.3%
Birch ( <i>Betula</i> B. pendula or B. pubescens)	15.1%
Norway spruce ( <i>Picea abies</i> )	4.8%
Pedunculate oak ( <i>Quercus robur</i> )	3.5%
Goat willow ( <i>Salix caprea</i> )	1.4%
Black alder ( <i>Alnus glutinosa</i> )	1.4%
Norway maple ( <i>Acer platanooides</i> )	1.2%
Ash ( <i>Fraxinus excelsior</i> )	1.2%
Willow ( <i>Salix</i> )	0.6%
Scots pine ( <i>Pinus sylvestris</i> )	0.3%
Small-leaved lime ( <i>Tilia cordata</i> )	0.3%
Elm ( <i>Ulmus glabra</i> )	0.1%

Also present: poplar (*Populus*), other trivial deciduous, European white-elm (*Ulmus laevis*), other hardwood deciduous, Field elm (*Ulmus minor*), hornbeam (*Carpinus betulus*) and larch (*Larix*).

**Regeneration**

Sometimes regeneration is done in gaps. In group-occasional system the maximum size of gap is 0.3 ha and total area of gaps shall not exceed 30% of the compartment's area. If group-selective cutting, the group (gap) size shall not exceed 0.1 ha. Repetition period shall not be less than 5 years.

Only natural regeneration is used.

**Site preparation**

No site preparation is used.

**Stand management**

**Pre-commercial thinning**



Stand-wise forest inventory records indicate that pre-commercial thinning was done on less than on 4% of the pre-commercial thinning age area during 2006-2015.

Silvicultural concepts shaping Lithuanian forestry principles in this FMM are primarily focused on development of fast growing, productive stands providing timber suitable for specific industries. The pre-commercial thinning in European aspen dominated stands is recommended to be started at age 10-14 when the tree differentiation into development classes is taking place. Green-bark form of aspen should be focused as it is more resistant to stem rot. Grey alder and Goat willow trees are recommended to be removed from the stand.

The pre-commercial thinning (based on data from stand-wise forest inventory from 2015 and using the functionality of integrated forest cadaster IS) should be carried-out on 44% of the area covered by forests of pre-commercial thinning age during 2016-2025. Assuming that the pre-commercial thinning in this FMM usually start when the stand age is >10 years, this means that in principle the share of the area where this FMM is applied should be pre-commercially thinned at least once during a rotation period does also equal 44%.

Formally, the stands under this FMM are under-thinned, i.e. the pre-commercial thinning is recorded just for few compartments. This may be explained both by low motivation of private forest owners to spend resources on pre-commercial thinning and specifics of the FMM, i.e. potential focus on timber use for fuel and unwillingness to invest in growing more commercially valuable forests.

### **Commercial thinning**

Stand-wise forest inventory records indicate, that the 1st commercial thinning was done on ~1% of the 1st commercial thinning age area during 2006-2015.

Only the 1st commercial thinning is possible due to low rotation period. The objective is to facilitate the increment, also aiming to develop the undergrowth and 2nd layer of relatively more valuable tree species.

The 1st commercial thinning (based on data from stand-wise forest inventory from 2015 and using the functionality of integrated forest cadaster IS) should be carried-out on 43% of the area covered by forests of the 1st commercial thinning age during 2016-2025.

We have to state significant under-thinning or even avoiding the 1st commercial thinning. In fact, there is rather limited commercial value of the timber harvested here and, assuming domination of private forests in this FMM, the reasons of being below formal silvicultural objectives, could be explained by lacking thinning motivation and, probably, discrepancies of current silvicultural concepts and the real life.

### **Pruning**

Pruning is not done in this FMM.

### **Harvest**



No harvesters are applied in non-clear cutting. Harvesting is basically done using chain-saws. Almost all extraction of timber is done by forwarders, however, some private forest owners for own timber utilization may not use fully mechanized wood extraction.

Use of logging residues are not utilized.

#### ***Nature protection***

FMM aims for continuous cover forestry (up to some extent). The Forest felling rules also requires leaving not less than 3 trees per ha with the age over MARA and the diameter over the average value for the compartment.

#### **5.16. Short rotation clear cutting in deciduous forests (aspen, grey alder) SRDEC\_C**

Clearcutting with deciduous trees are used on 3.2% of the CSA area. This is one of few FMMs with clear dominance of private forest owners (near 90%).

Three types of short rotation deciduous trees dominated stands were assigned to this FMM – over-mature low density European aspen dominated stands, stands on moist and wet soils and naturally regenerated pure grey alder and other low commercial value stands on usually productive soils.

Fuelwood supply is considered as the main ES, however, timber supply may also be considered to be important in European aspen stands, not damaged yet by the stem rot and under conditions of sufficient demand of wood for packaging.

This FMM is best illustrating the disagreement between Lithuanian forestry concepts, suggesting replacing low commercial value deciduous tree species on fertile soils by more valuable ones and the real life, involving different forestry objectives of private forest owners and non-industrial usage of the resources.

The rotation period for these tree species is not regulated in private forests.

Following the Lithuanian forestry principles, natural regeneration should dominate only in stands on moist and wet soils, while artificial regeneration should prevail (66-75%) in the remaining areas. In fact, natural regeneration dominates. Notably, some private owners follow the recommendations for artificial regeneration in a line with Lithuanian forestry principles.

Pre-commercial and commercial thinning are practically avoided.

Nature protection integrated in the stand-level management is associated mostly with leaving some live and dead trees in clear-cut areas.

#### **Edaphic conditions**

Mainly used on high production sites, 75% of the clearcutting model in deciduous stands are found on such sites.

#### ***Ecosystem services***

Fuelwood production is the main ecosystem service related to this FMM.

Forest management shall also secure biodiversity protection and provision of environmental protection and recreational (Forest Cutting Rules) and carbon sequestration services.

Timber supply may be considered to be important in European aspen stands, not damaged yet by the stem rot and under conditions of sufficient demand for the wood for packaging.

### ***Tree species and mixtures***

Pure or near pure stands should dominate stands managed with this FMM.

Based on Re-forestation and afforestation rules, the following tree species should be present on soils, occupied by forests belonging to current FMM:

- On dry sites with high productivity soils the following tree species should be targeted: Pedunculated oak, ash, Norway spruce, Small-leaved lime, Norway maple, elm, Norway spruce, Sessile oak, birch, European aspen and black alder.

- Dry with medium productivity: Norway spruce, Scots pine, larch spp., Pedunculated oak, Norway maple, Small-leaved lime, European beech, Sessile oak (*Quercus petraea*), birch spp.

- Mesic with high productivity: Norway spruce, birch spp., European ash, Pedunculated oak, Sessile oak (*Quercus petraea*), Black alder, Norway maple, Small-leaved lime, European aspen

Mesic medium productivity: Norway spruce, Scots pine, birch spp., Norway maple, Small-leaved lime, pedunculated oak, European aspen, Black alder

Tree species share the following volumes (no matter the main species):

Grey alder ( <i>Alnus incana</i> )	55.8%
European aspen ( <i>Populus tremula</i> )	29.3%
Birch ( <i>Betula -B. pendula or B. pubescens</i> )	6.6%
Pedunculate oak ( <i>Quercus robur</i> )	2.4%
Norway spruce ( <i>Picea abies</i> )	2.1%
Black alder ( <i>Alnus glutinosa</i> )	1.0%
Ash ( <i>Fraxinus excelsior</i> )	0.8%
Goat willow ( <i>Salix caprea</i> )	0.6%
Norway maple ( <i>Acer platanoides</i> )	0.4%
Willow ( <i>Salix</i> )	0.3%
Small-leaved lime ( <i>Tilia cordata</i> )	0.3%
Scots pine ( <i>Pinus sylvestris</i> )	0.2%
Elm ( <i>Ulmus glabra</i> )	0.1%
Poplar ( <i>Populus</i> )	0.1%

Also present: European white-elm (*Ulmus laevis*), hornbeam (*Carpinus betulus*) and larch (*Larix*), other trivial deciduous

### ***Regeneration***

There are 3 different types of short rotation deciduous stands associated with this FMM:



- Stands on moist and wet soils – such stands need to be naturally regenerated. E.g. stand-wise forest inventory data suggests natural regeneration during the period 2016-2025 on 99% of such area.
- Over-mature low density European aspen dominated stands. Stand-wise forest inventory data suggests natural regeneration during the period 2016-2025 on 25% of such area.
- Naturally regenerated pure grey alder and other low commercial value stands on usually productive soils. Stand-wise forest inventory data suggests natural regeneration during the period 2016-2025 on 33% of such area.

Establishment of stands on sites previously grown with aspen or grey alder is rather difficult and costly task. However, majority of areas under this FMM are privately owned and the major ES is considered to be fuel timber supply. Thus, hardly the objective to regenerate aiming for oak, ash, spruce forest should be applied in private forests, especially if the forest owner belongs to the household PFO type (cf. Stanislovaitis et al. 2015 for forest owner types). Thus, our expert judgement is that natural regeneration should dominate in this FMM. The share of naturally regenerated stands at pre-commercial thinning age is 76%.

### **Site preparation**

Site preparation is normally and most often not done.

### ***Stand management***

Silvicultural concepts shaping forestry principles in this FMM are primarily focused on development of fast growing, productive stands providing timber suitable for specific industries.

### **Pre-commercial thinning**

The pre-commercial thinning in European aspen dominated stands is recommended to be started at age 10-14 when the tree differentiation into development classes is taking place. Green-bark form of aspen should be focused as it is more resistant to stem rot. Grey alder and Goat willow trees are recommended to be removed from the stand. As the majority of forests under this FMM are privately owned and the assumed main ES is fuelwood supply, no thinning could also be suggested as well.

The pre-commercial thinning (based on data from stand-wise forest inventory from 2015 and using the functionality of integrated forest cadaster IS) should be carried-out on 30% of the area covered by forests of pre-commercial thinning age on wet soils during 2016-2025. Naturally regenerated pure grey alder and other low commercial value stands are suggested to be pre-commercially thinned on 9% of the area covered by forests of pre-commercial thinning age.

### **Commercial thinning**

Stand-wise forest inventory records indicate, that the 1st commercial thinning was done on less than on 1% of the 1st commercial thinning age area during 2006-2015.

We have to note under-thinning or even avoiding the commercial thinning, no matter very low requirements for the areas to be thinned. In fact, there is rather limited commercial value of the

timber harvested here and, assuming domination of private forests in this FMM, the likely reasons could be lacking thinning motivation by private forest owners and discrepancies of current silvicultural concepts and the real life.

### **Pruning**

No pruning is done in this FMM.

### **Harvest**

Harvesting is basically done using chain-saws. Almost all extraction of timber is done by forwarders, however, some private forest owners for own timber utilization may not use fully mechanized wood extraction. Logging residues are not collected, extracted and used.

### **Nature protection**

At least 7 live trees (among them at least 3 trees need to be older or having DBH larger than the average value for the whole stand) per 1 ha and 3 dead trees (DBH > 20 cm) per 1 ha shall be left in clear-cut areas over 1 ha. For clear-cut areas 0.5-1 ha, the figures are, respectively, 3 (2) and 2. Biodiversity trees are left in clear-cut areas for natural decay. Also stand level restrictions are introduced due to woodland key habitats, presence of nests of some birds.

## **5.17. Management in special purpose forests**

The main ecosystem services associated with this FMM are sustaining and recovering of forest ecosystems or specific components of ecosystems and recreation and all forests belong to Group II (Special purpose forests). Key forest management principles in special purpose forests are regulated by the Forests Law and other supporting legal acts, leaving limited flexibility for forest manager. Non-uniform shelter-wood management system mostly resembles the group-selective cutting system that dominates in this FMM.

13.4% of forests in the CSA belongs to this FMM and near two-thirds of them are state owned. The area under this FMM should remain stable, as it is much predetermined by forest groups. Majority (~95%) of forests under this FMM belong to Ecosystem protection forests whose area may be changed only involving revision of forest groups or grouping principles.

Rotation periods are based on natural maturity age that is approx. 60% higher than the MARA in commercial forests. As non-clear harvesting is carried-out during a long period throughout the whole stand, there are no limitations regarding the area harvested at one time-point, however the gaps cut are very small, not exceeding 0.1 ha.

All soil conditions present in the CSA are represented in this FMM as the diversity of tree species present is very high. Species, making more than 5% of standing volume, are Norway spruce, birch spp., Scots pine, Black alder, Grey alder, Pedunculated oak, and European aspen.

Artificial regeneration dominates in state forests, while the natural regeneration dominates in private forests. There are numerous cases where natural regeneration is not possible, e.g. due to low regeneration capacity at natural maturity age.

The objective for stand management in this FMM is to improve the ecological, aesthetic, recreational and other forest functions and to develop conditions for sustaining the objects under protection, recovering and maintaining biological diversity in the forests, thus, very diverse treatment solutions may be used. The pre-commercial thinning is practically at the level required by silvicultural requirements in state forests, however, practically no pre-commercial thinning is done in private forests. The commercial thinning in state forests is slightly under optimal amounts, however, only very few private forest owners do pre-commercial thinning in special purpose forests.

### ***Edaphic conditions***

The management model is used on all site, fertile and unfertile from wet to dry.

### ***Ecosystem services***

The main aim with this management system is sustaining and recovering of forest ecosystems or specific components of ecosystems. Also recreation is an aim with this model, recreation is important on ~5% of the FMM area.

### ***Tree species and mixtures***

Tree species share (%) the following volumes (no matter the main species):

Norway spruce ( <i>Picea abies</i> )	37.4
Birch (Betula -B. pendula or B. pubescens)	18.9
Scots pine (Pinus sylvestris)	15.8
Black alder (Alnus glutinosa)	9.0
Grey alder (Alnus incana)	6.0
Pedunculated oak (Quercus robur)	5.7
European aspen (Populus tremula)	4.4
Norway maple (Acer platanoides)	0.8
Small-leaved lime (Tilia cordata)	0.7
Ash (Fraxinus excelsior)	0.5
Elm (Ulmus glabra)	0.3
Hornbeam (Carpinus betulus)	0.2
Goat willow (Salix caprea)	0.2
Willow (Salix)	0.1
Larch (Larix)	0.1

Also present: European white-elm (*Ulmus laevis*), other softwood and hardwood deciduous, Jack pine (*Pinus banksiana*), Field elm (*Ulmus minor*) and poplar (*Populus*).

### ***Rotation period***

The Forest cutting rules allow also non-clear occasional cutting in the type of stands where this model is used. There are no regulations nor experience on implementation. Free-selective cuttings,



which resemble best the B – uniform shelter-wood system is also applied in recreational forests, which are in minority in this FMM.

### ***Regeneration***

Artificial regeneration in state forests dominates. However, even if the target is to maximize natural regeneration, there are numerous cases where it is not possible. MARA in this FMM is usually associated with natural maturity age and trees at maturity age sometimes have already lost the regenerating capacity. Thus, the only option is to use artificial regeneration.

The area of artificial regeneration during last decade in state forests was 72.2 ha, in private forests – 9 ha. Natural regeneration during last decade in state forests was 44.7 ha, in private forests – 51 ha. Thus, the share of natural regeneration is ~38% in state forests and 85 % in private forests.

### **Site preparation**

Soil scarification could be applied to facilitate the regeneration in some minor locations. Currently no soil scarification is applied. Telsiai SFE has scarified soil previously soil to facilitate the regeneration in Zemaitija National Park, however, the response from the park was strongly negative

### ***Stand management***

The main objective of thinning under this FMM is to improve the ecological, aesthetic, recreational and other forest functions and to develop conditions for sustaining the objects under protection, recovering and maintaining biological diversity in the forests. This FMM includes rather large diversity of forest conditions

### **Pre-commercial thinning**

It is rather difficult to suggest the required extents of pre-commercial thinning.

The pre-commercial thinning is practically at the level required by silvicultural requirements in state forests, however, practically no pre-commercial thinning is carried-out in private forests. Assuming that the FMM covers special purpose forests, private forest owners hardly are motivated to seek the thinning objectives - improve the ecological, aesthetic, recreational and other forest functions, etc.

Based on data of stand-wise forest inventory from 2015, the pre-commercial thinning is suggested for the next decade to be implemented on 220.8 ha (47% of the area covered by stands of pre-commercial thinning age) in state forests and 66.3 ha (47%) in private forests.

The forest management project for Telsiai SFE for the period 2006-2015 suggested the pre-commercial thinning on 313 ha (46% of the area covered by stands of pre-commercial thinning age).

### **Commercial thinning**

Based on data of stand-wise forest inventory from 2015, the 1st commercial thinning is suggested for the next decade (2016-2025) to be implemented on 196.5 ha (31% of the area covered by stands of the 1st commercial thinning age) and the 2nd commercial thinning is suggested for the

next decade to be implemented on 391.5 ha (22 % of the area covered by stands of the 2nd commercial thinning age) in state forests. The figures for private forests are, respectively, 192.2 ha (52 %) and 408.2 ha (26 %).

According to the forest management plan for Telsiai SFE for the period 2006-2015, the 1st commercial thinning was suggested on 265 ha out of 604 ha (44%), the 2nd commercial thinning – on 132 ha out of 1432 ha (9%). The suggested area for thinning is estimated based on silvicultural requirements valid in Lithuania.

According to the records from stand-wise forest inventory, the 1st commercial thinning in state forests was done on 187 ha (31% of the area covered by stands of the 1st commercial thinning age). The 1st commercial thinning in private forests was done on 10.1 ha only. The 2nd commercial thinning in state forests was done on 130.7 ha (9% of the area covered by stands of the 2nd commercial thinning age). The 2nd commercial thinning in private forests was done on 23.4 ha.

The commercial thinning in state forests seems to be slightly under suggested amounts and only very few private forest owners do pre-commercial thinning in special purpose forests. Assuming the specifics of thinning under this FMM, private forest owners hardly are motivated to seek the thinning objectives - improve the ecological, aesthetic, recreational and other forest functions, etc.

### **Pruning**

No Pruning is done in stands managed with this model.

### **Harvest**

Chain saws dominate. Almost all extraction of timber is done by forwarders, however, some private forest owners for own timber utilization may not use fully mechanized wood extraction.

Use of logging residues are collected and extracted.

### **Nature protection**

The main purpose with this management model is sustaining and recovering of forest ecosystems or specific components of ecosystems, thus all forestry is focusing on nature protection. No clear-cutting, final cutting at natural maturity age, regeneration and thinning approaches, harvesting technologies – all they are aimed for nature protection first. Additionally, the Forest cutting rules require leaving not less than 3 trees per ha with the age over MARA and the diameter over the aver-age value for the compartment.

### **5.18. Stands with no intervention**

This is not really a model for management as no intervention are done. 3.2% of the CSA area is assigned to “no intervention” or no management. It assumes leaving forest ecosystems for natural succession in their natural state, thus no human intervention is allowed. Majority of forests with no intervention belong to the state and are managed by Telsiai SFE. The ecosystem service is biodiversity protection and biosphere monitoring. All edaphic conditions as well as all tree species found in CSA are represented in this FMM. Most common tree species are Norway spruce, Scots pine and birch spp.

NEPCon Interim Standard for Assessing Forest Management in Lithuania (2014) requires that the forest management enterprise shall leave representative samples of existing rare and/or endangered ecosystems for natural succession in their natural state covering at least 5 % of the total forest area. As only 40% of the CSA is belongs to state and is managed by Telsiai SFE, the area with no intervention meets the certification requirement. Less than 1% of private forests (~160 ha) belongs to this FMM.

As the areas assigned for this FMM were identified using data from recent stand-wise forest inventory (year 2015), it is accepted that all values requiring no intervention status were considered during the inventory and the share of this FMM is at its proper level.

### ***Edaphic conditions***

The reserves should be represented by all site type, fertility and soil moisture, what opens the possibility for the conservation of maximal species amount (Margules and Nicholls 1988, Possingham, Ball and Andelman 2000). Though we see a slightly irregular distribution of the reserves areas within the CSA. The reserve network is state-wide and is distributed within the whole country, so the sites, which are poorly represented within the CSA, can be more widely represented in other reserves in Lithuania. A low percent of highly-productive moist sites under this FMM can be explained by the fact that such sites usually form after artificial draining of the wet sites, which is followed by plantation forestry.

### ***Ecosystem services***

Biodiversity protection and biosphere monitoring.

### ***Tree species and mixtures***

The species admixture level will form itself depending on the site conditions, original tree composition and other similar factors.

In the stands (reserves) tree species distributions (%) and volume (th - thousand m<sup>3</sup>) are:

Norway spruce ( <i>Picea abies</i> ) –	42.7%,	280th. m <sup>3</sup>
Scots pine ( <i>Pinus sylvestris</i> ) – 3	3.2%,	217th. m <sup>3</sup>
Birch ( <i>Betula</i> - <i>B pendula</i> or <i>B pubescens</i> )	9.3%,	61th. m <sup>3</sup>
Black alder ( <i>Alnus glutinosa</i> ) –	7.4%,	49th. m <sup>3</sup>
Pedunculate oak ( <i>Quercus robur</i> ) –	4.1%,	27th. m <sup>3</sup>
Grey alder ( <i>Alnus incana</i> ) –	1.3%,	8th. m <sup>3</sup>
European aspen ( <i>Populus tremula</i> ) –	1.1%,	8th. m <sup>3</sup>
Small-leaved lime ( <i>Tilia cordata</i> ) –	0.4%,	2th. m <sup>3</sup>
Ash ( <i>Fraxinus excelsior</i> ) –	0.3%,	2th. m <sup>3</sup>
Elm ( <i>Ulmus glabra</i> ) –	0.1%,	1th. m <sup>3</sup>
Norway maple ( <i>Acer platanoides</i> ) and hornbeam ( <i>Carpinus betulus</i> ) –	under 0.1%	

### ***Rotation period***

Harvesting is prohibited. No intervention allowed due to Forest Law requirements.



### ***Regeneration***

As long as no intervention is allowed, the regeneration in modern reserves is only natural. However, these reserves could be founded in the areas where previously were managed/planted forests.

### ***Stand management***

No intervention is allowed

### ***Harvest***

No harvest

### ***Nature protection***

The whole idea is dedicated mainly to nature protection. The forest is left to grow naturally, without any human intervention and sometimes with visiting limitations.

## **5.19. References**

### ***Personal communication:***

Forest management planning experts from State Forest Inventory and Management Planning Institute (SFIMPI) were interviewed (M.Lynikas, V.Beržanskis). The experts are right now working with the elaboration of forest management plan for the CSA.

2 experts from Telsiai SFE were interviewed – deputy director (A.Jokužys), who is in charge of forestry issues and forest regeneration engineer (L.Servienė).

Information collected within the frames of conventional stand-wise forest inventory, conducted in 2015 and describing also the forestry activities during 2006-2015.

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