Deliverable 1.1 – FMM descriptions (in report form)

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Project Coordinator	Ljusk Ola Eriksson, Swedish University of Agricultural Sciences (SLU)
Scientific Coordinator	Vilis Brukas, Swedish University of Agricultural Sciences (SLU)
Project Administrator	Giulia Attocchi, Swedish University of Agricultural Sciences (SLU)
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Summary

This report maps Forest Management Models (FMMs) that are applied on 10 Case Study Areas (CSAs) within 9 countries of the ALTERFOR consortium, namely: Germany (2 CSAs), Ireland, Italy, Lithuania, the Netherlands, Portugal, Slovakia, Sweden and Turkey. Besides the description of their main silvicultural features, FMMs are ranked according to their capacity to provide different ecosystem services. In addition, available technology and knowhow and restrictions set by legislation were described in a so called "Technological landscape" analysis. The report serves two primary aims. Internally, it serves the ALTERFOR partners by establishing an overview of prevailing silvicultural practices that will serve as the benchmark descriptions when examining the alternative FMMs at the later stages of the project. Externally, the thorough and systematic mapping of current FMMs and their effect on ecosystem services might serve any reader interested in approaches to forest management as currently applied under a variety of ecological, technological and socio-economic conditions on the European continent.

The FMM descriptions, effects on ecosystem services and technological landscapes were elaborated by multidisciplinary research teams in the case countries. FMM descriptions were based on a structured questionnaire consisting of two main parts: (i) a background description of the historical milestones that lead to the currently dominant FMMs in respective countries and CSAs; (ii) the detailed descriptions of the FMMs, classified according to the most common silvicultural systems. Each FMMs is dissected by the most important silvicultural measures. In subsequent analysis, FMMs on each CSA were ranked for the following ecosystem services: biodiversity, carbon sequestration and substitution, water quality, flooding and water availability, cultural services and regulatory services.

The descriptions expose a large variety of FMMs applied on different CSAs which to a large extent are conditioned by different historical contexts and current socio-economic drivers. The number of the reported FMMs differ from 1 (Italy) to 12 (Lithuania) which can be explained by several factors including the area of a CSA; the actual heterogeneity of silvicultural practices; and the different degrees of aggregating the silvicultural practices within an FMM. According to our mapping, clear felling, shelterwoods and selective cutting aiming at heterogeneous forests are the most prominent silvicultural systems, together occupying around 73% of the forest area on all CSAs. Various coppice methods occupy around 10% of the area and no intervention around 5%. Around 12% of the area was either a combination of silvicultural methods or does not fit in any of the above categories. FMMs aiming at homogeneous forests account for about 39% of the area whereas FMMs aiming at heterogeneous stands made up about 33% of the area. However, the distribution of the silvicultural systems vary considerably between countries. FMMs aiming at homogeneous forests dominate in e.g. Ireland, Portugal and Sweden, contrary to e.g. Germany, Slovakia and Italy where the dominating FMMs are more favourable for heterogeneous forests.

Ecosystem services are affected by FMMs primarily via tree species, stand structure and interval of interventions and rotation length. The overall picture was that FMMs dominated by broadleaves got higher ranking for several ecosystem services than stands dominated by conifers and that the different coppice systems got lower ranking for several ecosystem services than other FMMs.

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FMMs resulting in a heterogeneous stand structure tended to have a higher overall ranking than FMMs resulting in homogeneous stands. However, the comparison between FMMs for ecosystem services is problematic since both the ranking of ecosystem services and FMMs depend on site characteristics. Another problem is that the ecosystem services may be in conflict with each other.

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I. Forest Management Models (FMMs) description

Abbreviations used

AWF – Augsburg Western Forest (Germany)
BAU – Business as usual
CC – Clearcutting
CCF – Continuous Cover Forestry
CS – Cultural Services
CSA – Case study Area
DSS - Decision Support System
ES – Ecosystem Services
FMM – Forest Management Model
FPM – Freshwater pearl mussel
FSC – Forest Stewardship Council
FVZ – Forest Vegetation Zone (Slovakia)
IFM – Integrated Forest Management (the Neatherlands)
LCC – Local Case Coordinator
LFN - Lieberose Schaubetal Neuzelle (Germany)
MAI – Mean Annual Increment
MARA Minimum Allowable Rotation Age
NGO - Non-Governmental Organizations
NP – National Park
NWS – Native Woodland Sites
PCT – Pre-Commercial Thinning
PEFC - The Programme for the Endorsement of Forest Certification
SFE - State Forest Enterprise (Lithuania)
SFIMPI - State Forest Inventory and Management Planning Institute, (Lithuania)
WP – Work Package
ZIF Forest Intervention Zones (Zonas de Intervenção Florestal) (Portugal)

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1. Introduction

1.1. What is a forest management model (FMM)?

The concept of Forest management models (FMMs) or forest management approaches has met increasing interest in forest literature the last decades (Dunker et al 2012; Hengeveld et al 2012). Foresters have for a very long time discussed silviculture systems, e.g. (Mathews 1989). There is no clear distinction between silviculture systems and FMMs, see (Duncker et al 2012) for a discussion. What is a silviculture system? Mathews (1986, p3) defines it as "*The process by which the crops constituting a forest are tended, removed, and replaced by new crops resulting in the production of stand of distinctive form*".

Different authors discuss and describe silviculture systems using different approaches, e.g. (Daniels 1979, Fujimori 2001). One way to identify and categorize silviculture systems is based on the origin of trees, from seed or vegetative (suckers or coppice). Another way is the use of trees, if trees are harvested mainly when they reach a mature size or if small dimensions are harvested. The terms high forest and low forest are then often used. Yet another approach is based on the main methods of removing trees. Are all trees removed in one final harvest, a clearcut, or are trees harvested selective in some way? With different terminology and the possibility to combine operations, it is easy to imagine the possibilities for confusion. Classification of silviculture systems result in a large European project in itself.

One common classification contains the following categories: clear-felling, shelterwood, selective and coppice systems (Matthews, 1989, Fujimori, 2001). Each system includes different operations that can be varied and together there is a very large number of combinations.

The use and outcome of silviculture systems are dependent on the environment, the growing conditions and tree species, on economic and social situation as well as legislation. A system used in one part of Europe can in practice be different in another environment. A silviculture system can be described as a toolbox, it includes many activities or tools, used in different phases of the stand development. Such tools are for example soil preparation and thinning, but many of the tools or activities can be used in many systems.

A key concept in the ALTERFOR work is Forest Management Models. Today it is common to talk about Ecosystem Services (ESs) connected to forest. ALTERFOR will scrutinize the possibilities to increase different ESs from forestry. In a first step FMMs will be identified and described.

1.2. Data collection

During autumn 2016 the local case study coordinators described the CSA and the FMMs used. This was done by a questionnaire common for all partners. As a help examples form Lithuania and Sweden were available. The questionnaire had two parts, a general description of the CSA, areas, trees species and more, see appendix part1.

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Description of FMMs was done by using a detailed questionnaire, one for each FMM, see appendix part2. The FMMs were classified in one of the groups; Clear cutting systems, Uniform shelterwood systems, non-uniform shelterwood systems, selection systems, coppice systems, or no intervention. Information about the models and to what extent they are used, tree species and important forest management measures were collected. Many questions are divided in two parts; present situation and by LCC recommended situation.

1.3. FMMs in different countries

There is a large variation in the forestry and silviculture in the participation countries. The number of described FMMs used in the CSAs differ considerably, from 12 in Lithuania to one in Italy (Table 1 and Table 2).

Table 1 Number of reported FMMs for each partner

Country	No of FMMs	Total area CSA, ha	Forest area of CSA, ha
Germany, Bavaria	3	120 000	51 600
Germany, Brandenburg	3	60 000	22 200
Ireland	3	77 528	12 511
Italy	1	315	291
Lithuania	12	253 970	88 195
The Netherlands[1]	9	4 154 300	373 500
Portugal	4	14 850	14 474
Slovakia	10	151 768	94 855
Sweden	6	840 000	704 000
Turkey	8	81 808	40 493

[1] Encompasses the entire country.

Table 2 Name and identification, all FMMs reported

Country	FMM name	FMM ID
Germany, CSA: Augsburg, Bavaria	Beech State Forest	
	Spruce Large Private	
	Spruce State Forest	
Germany CSA Librose-Schlaubetal-Neuzelle Brandenburg	Scots Pine Private Forest-	
	Oak Stat Forest	
	Scots pine state forest	
Ireland	Clearcutting conifers	

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Country	FMM name	FMM ID
	Clearcutting lodgepole pine	
	Nature conservation and biodiversity protection	
Italy	Selective systems	
Lithuania	Aspen Greyalder Clearcuttning	SRDEC_C
	AspenGreyalder Uniform shelterwood/Clearcutting	SRDEC_CUS
	Birch BlackAlder Clearcutting	MRDEC_C
	Birch Blackalder UniformShelterwood Clearcut	MRDEC_CUS
	No intervention	NOINT
	Pine Clearcutting	LRCON_C
	Pine Uniform shelterwood	LRCON_C
	Pine Uniform ShelterwoodClearcutting	LRCON_CUS
	Special PurpouseForests	SPECP
	Spruce Clearcutting	MRCON_C
	Spruce non UniformSheltrwood	MRCON_NS
	Spruce NonUniform ShelterwoodClearCutting	MRCON_CNS
The Netherlands	NatureForest Broadleaved	
	NatureForest Oak	
	NatureForest Pine	
	NatureForest Conifers	
	ProductionForest Broadleaved	
	ProductionForest Oak	
	ProductionForest Conifers	
	ProductionForest Pine	
	Other Forest	
Portugal	MartinePineEucalyptus	
	Eucalyptus Maritime Pine	
	Chestnut	
	Eucalyptus pulpwood	
Slovakia	oak wood provision	I
	oak beech timber	II
	beech timber	III
	fir beech wood and timber	IV
	nature conservation and biodiversity protection	IX
	spruce fir beech timber	V
	spruce fir beech close to nature	VI
	spruce timber	VII
	soil protection	VIII

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Country	FMM name	FMM ID
	water purification	IX
Sweden	clearcutting intermediate final	SE1
	clearcutting long final	SE2
	clearcutting short final	SE3
	nature conservation with management	SE4
	uniform shelterwood system final	SE5
	nature conservation withoutr management	SE6
Turkey	clearcutting	
	conversion coppice	
	long shelterwood	
	Medium rotation coppice	
	nature with intervention	
	no intervention	
	short coppice	
	very long shelterwood	

The most common silviculture systems among the FMMs are the clearfelling (13) and non-uniform shelter system (12). Selective systems are not used very often, four FMMs are described as selective models. Coppice is used in 4 models, together with clearfelling system of an admixture in two other models and also one model for conversion from coppice to clerfelling model.

Clearfelling systems and uniform shelter systems both result in even-aged forest, at least for most of the rotation period. These two systems are used in 22 FMMs and an estimated area of 39% Table 6.

Selective systems and non-uniform shelterwood system both result in uneven aged forest. These two systems are used in 16 FMMs and in 4 systems combinations with selective or non-uniform shelterwood systems. Totally 20 FMMs with uneven-aged forest are estimated to cover 33% of the area. Clearfelling systems are used on 23% of the area, and selective systems on 13%, non-uniform systems on 12%, for more information see Table 3.

Table 3 FMMs classified in silviculture systems, number of FMMs and estimated proportion of area where they are used. The sum is not 100%, as all alternative FMMs are not described.

Silviculture system	Nr of FMMs	Estimated cover %, total all CSA[1]
clearfelling	13	23
uniform shelter	9	16
selective	4	13
non-uniform shelter	12	12
more than one selective[2]	4	9

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coppice	4	7
combination with coppice	2	3
transformation from coppice	1	0.3
no intervention	6	5
not defined (or combination of two or more systems[3])	4	1.5

[1] Not weighted by area of CSA instead assuming each CSA have equal size.

[2] Selective, two or more systems combined at least one selective resulting in uneven-aged forests

[3] Not selective systems

1.4. References

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II. Ranking of Ecosystem Services (ES)

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1. Introduction to methodology

1.1. Ecosystem services and FMMs

Ecosystem services (ES) were ranked for each current stand-level FMM. A simple and efficient approach was used for providing an approximate ranking of the current stand level FMMs for each of the ES assessed in each ALTERFOR partner. Each ES leader provide a method, based on some important components connected to ES. The methods behind the ranking are built upon modified versions of the ES guidelines, adapted specifically to enable each participating LCC to evaluate the relative ES provisioning capacity of their FMMs, with or without the use of DSS.

The ES were biodiversity, carbon sequestration, cultural services, regulatory services and water related services. Important factors connected to and describing the ES was listed as help for the LCC to do the ranking. The ES experts used different number of factors or indicators. For example for biodiversity three indicators were recommended to use, while for carbon sequestration 18 attributes was listed. Indicators used differ between CSAs. For example risk for fire was used mainly in CSAs situated in south Europe.

The ranking of ES was done for CSA and FMMs can be compared within a CSA but not between CSAs. A high ranking of a FMM in one CSA does not indicate that it better than a corresponding FMM in other CSA.

1.1.1. Biodiversity

Here we do not rank biodiversity per se but rather habitat provisioning capacity in production forests. To do this, three key determinants of habitat available were identified and recommended to use. The components, all important for biodiversity were: tree species composition, forest structure and spatial-temporal disturbance patterns. Partners could use additional factors necessary to consider when evaluating habitat availability but it was suggested to limit the numbers or indicators used.

A scale from 1 to 7 was used. The average of these three scores gave a ranking.

The average of the indicator gave scores for each FMM to provide the resultant rank. Two distinct FMMs can result in the same or similar summary scores, provided this outcome is consistent with the FMMs being approximately equal in biodiversity value. An equivalent biodiversity value does not indicate that the same species will benefit. It only indicates an approximate equivalence in terms of closing the targeted gap between the habitat requirements of native flora and fauna (the biodiversity goals as above), and the habitat provision of an FMM.

1.1.2. Carbon

FMM ranking was based on the capacity to sequester carbon in forest and in forest products. Carbon can be stored in living pools, above ground and below ground, in deadwood and also in harvested material. Availability of data was an important limiting factor, which was of the reasons

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to allow each case study team to adapt the analysis according to the existing conditions and data available for each CSA.

1.1.3. Cultural

Cultural services were ranked based on six key factors or concepts. They were: stewardship, naturalness/disturbances, complexity, visual scale, historicity/imageability and ephemera (Table 1).

Table 1 Indicators used for evaluation of cultural services for stand level FMMs

Concepts	Dimensions	Attribute	Indicator used	Data source	Direction
Stewardship	Sense of care	Amount of residue from harvesting and thinning	index (absent (0), low (0.25), medium (0.5), considerable (0.75), high (1))	expert judgement	negative
Naturalness/ disturbances	Alteration /impact	Area of final felling	Stand size index (<0.1 ha (0) to > 0.5 ha (1)	area class index	negative
Naturalness/ disturbances	Alteration/ impact	Frequency of final felling	Frequency index (0 = very often to 1 = no final felling)	expert judgement	negative
Naturalness/ disturbances	Natural Value	Naturalness of forest stands	hemeroby index (0 = natural, to 1 = monoculture, plantations)	Expert judgement	negative
Naturalness/ disturbances	Wilderness	Amount of natural dead wood	volume of standing deadwood	dead_volume_m3_ha	positive
Naturalness/ disturbances	Intrusion	Naturalness of forest edges/edge effects	index (straight edges (0), to inherent, natural borders (1))	expert judgement	positive
Complexity	Diversity	Tree species diversity within stand	shannon diversity index	shannondivindex	positive
Complexity	Variety	Variation of tree size within stand/age structure	CV of dbh	CV_dbh	positive
Complexity	Spatial pattern	Variation in tree spacing within stand	index (Regular (0), to irregular (1))	expert judgement	positive
Visual scale	Openness	Visual penetration/density of obstruction	Number of trees per ha	live_stemdensity_ha	negative
Visual scale	Visibility	Presence of understory in stand	Understory cover index (none (0), to > 50% (1))	understory_c	negative
Historicity/ imageability	Historical richness	Age of trees in stand	Stand age	age	positive
Historicity/ imageability	Historical continuity/ place identity	Age of current landuse	Number of sequential historical maps showing forest	GIS-Work to be done	positive

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Concepts	Dimensions	Attribute	Indicator used	Data source	Direction
Ephemera	Seasonal change	Presence of broadleaves	Percentage of coniferous trees	coniferous_fraction_ba	negative

Many of these factors consist of more than one attribute. A list of the 14 attributes are presented in Table 1. Some of the indicators were calculated e.g. **Shannon** index, some judged by experts. Some of these indicators indicate similar things, e.g no intervention are positive for "stewardship" and naturalness while visual scale/openness are in conflict with complexity and naturalness.

1.1.4. Regulatory

Regulatory services deal with risk for trees, stands and forestry. The ranking of the risk for different risks based on expert judgement, also supported by earlier research and information regarding the local forest management practices. The ranking should be based on general characteristics of the different FMMs. The importance of various risks differs a lot among CSAs, therefore different case study teams use different priorities in the risk analyses. Most typical and most frequently reported are risk for winddamages. Other risk factors included in the reports are risk for fire, bark beetles, snow, and diseases.

1.1.5. Water

Detailed quantifications of FMM effects on water provision were not possible given the time and resource constraints within the project. Therefore, the analysis relied on expert judgement. In most cases the judgement was done by a group of researchers consisting of several different fields of expertise. The indicators were: water yield, flood protection, water flow maintenance, erosion control and chemical conditions.

1.2. Summary of findings

1.2.1. Biodiversity

Tree species composition was an indicator evaluated and should have an effect on the result. But the differences are in many cases not large. In general, mixed stands got a higher ranking for biological values. An example of this is Ireland, where pure conifer stands got ranking, 2, spruce with admixture of other conifers got 2.67 and in admixture with deciduous trees 3.33 (Table 7). The Italian CSA reported ranking 4 for pine stands and 4.7 for mixed forest within the same FMM (Table 12). In Sweden, in FMM with intermediate rotation pure spruce 2.0, pure pine 3.0, mixtures of pine and spruce 3.5 and mixtures including deciduous 3.8 (Table 39). The small differences indicate that the available tree species and proportions of their mixtures are only one among many factors that influence biodiversity values.

The overall picture is that stands and FMMs dominated by broadleaves got a higher ranking than FMMs dominated by coniferous. An example of this is Turkey where FMMs including pine got ranking of 2.66 and 3.0 while FMMs characterised by high forest of broadleaves hade rankings from 4.66 to 5.66. On the other hand, it also illustrated that tree species itself don't give high biodiversity as coppice with oak and chestnut got the lowest values of all in Turkey, 1.66 and 2.66 respectively, (Table 47). An example for Germany shows that management can be more important than tree

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species. Pine and spruce forest managed by private owners got ranking 1.7 and 2.0 while pine and spruce managed by state got ranking 5.2 and 5.0 respectively, (Table 2).

There is trend that rotation period have an effect of forest structure and disturbance regime and FMMs with longer rotation have in general a slightly higher ranking but the differences are very small. Lithuania and Sweden have used rotation period to classify FMMs. The three FMMs in Lithuania with long rotation have in average a ranking of 3.5, five with medium rotation 3.5 and with short rotation 3.1. The figures for Sweden are 5.0, 3.1 and 2.3 for FMMs with long, medium and short rotation, respectively Table 39. It is important to take into consideration that rotation period and trees species are closely correlated and the figures above indicate not only the influence of rotation but also tree species.

The overall trend is that coppice systems have lowest ranking of biodiversity, clearcutting systems follows and highest values have selective systems. Non-uniform shelter system and models combining one or more systems also have high ranking. The example from Turkey indicates that biodiversity score reduced with coppice system (Table 47) and the examples from Germany (Table 2) and Lithuania (Table *23*), where selective systems and clear-felling systems are compared, show a higher ranking of selective systems.

It is not possible to separate the effect of the system itself from the tree species and the rotation periods. Coppice systems in general have short rotations and is used with only some species, clear-felling systems are often used for coniferous and selective systems are often used with deciduous trees or mixtures.

1.2.2. Carbon

It is a general agreement among scientists that forest may play an important role in mitigating climate change through carbon sequestration and through substitution effects. However, there is less agreements when it comes to which FMMs are is best for the combined effects of sequestration and substitution. This is also shown in this evaluation of the effects on carbon sequestration and substitution of various FMMs in the CSAs.

Both carbon sequestration and substitution depend on growth, harvest and on how the harvested products are used. With increased growth, biomass can either be stored in living trees or be harvested with subsequent substitution effects. Therefore, assumptions about differences in growth between FMMs will be very important for the carbon sequestration and substitution ranking of FMMs. Substitution can of course be higher if growth is high and if a large part of the growth is harvested. In addition, substitution depend on the products and how they are used and are higher for long-lived products replacing carbon intensive materials such as concrete or steel than for short-lived products like paper and bio-energy.

In this analysis, different silvicultural systems are compared. Therefore, storage of carbon in living biomass must be equalized. A continuous cover forest will of course have higher carbon storage when compared to a clearcut but not when compared to an old Norway spruce stand just before final felling. Therefore, it is necessary to compare storage and substitution over a whole generation for clearcutting (CC) systems and over several cutting cycles for continuous cover systems (CCF) and to include sources of carbon such as decomposition of harvest residuals on clear-cuts.

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A final remark before the individual CSAs estimate of carbon sequestration and substitution is that mitigating climate change can only be done if the combined effects of sequestration and substitution are increased compared to an initial value. The climate mitigation effects of a second-generation Norway spruce plantation will increase compared to the previous generation if the harvested biomass is used more efficiently from a substitution point of view (i.e. building material instead of paper) or if growth is increased (i.e. by the use of improved genetic material or fertilization). Conversion to continuous cover system from a homogeneous clearcutting system will increase mitigation if growth is increased or if the average landscape net effect of carbon storage in living material, carbon storage in the soil and carbon release during decomposition is increased.

Another complicating variable when it comes to comparing mitigation effects of different FMMs is that different FMMs are suitable on sites with different properties. On average, growth is lower for Scots pine than for Norway spruce which makes the former tree species less suitable for mitigating carbon. However, the difference in growth is mainly because Norway spruce is grown on fertile soils whereas Scots pine often is grown on dry and more infertile soils. Therefore, these tree species are not always exchangeable and it is difficult to compare them with regard to climate change mitigation.

With all the above difficulties, an attempt was made to rank the different FMMs in each CSA with respect to carbon sequestration and substitution. In most cases, the ranking was done using a 5- or 7-level scale but the variables used for the ranking varied between CSAs. In some cases, the ranking was based on simulation with a decision support system but in most cases expert judgement was used.

In many of the CSAs, the combined ranking varied relatively little between the different FMMs. In Germany, ranking varied between 3.5 and 5.5 on a 7-level scale. However, the lowest ranking was given to Scots pine forests which probably was due to lower site productivity in these forests. The Slovakian and Swedish CSA also used a 7-level scale and here most of the FMMs received average ranking between 3.5-5.5. On a 5-level scale, the ranking varied between 2.17 and 3.04 in Ireland and between 1.7-1.9 in Italy.

From the ranking, it is difficult to find FMMs in the individual CSAs that are substantially better than others from a climate change mitigation point of view. One reason for this is that so many variables are affecting sequestration and substitution and that these variables often are in conflict with each other. E.g. in the Slovakian CSA, the fir-beech FMM has high score on biomass production but a low score on substitution whereas the oak-timber FMM has a low score on biomass production and high score on substitution. The net effect of the overall assessment was that both FMMs received about equal overall rating.

A problem with this kind of ratings is that all variables have the same weight irrespective of the importance for sequestration and substitution. Therefore, it would be good to use a weight for the variables depending on their importance for either sequestration or substitution.

It is possible to compare similar FMMs over the different CSAs. In Germany, oak and beech FMMs received the highest rankings whereas in Sweden, the Norway spruce plantation FMM received higher ranking than the oak FMM. In Ireland and Sweden, the no intervention FMMs received low rankings while a similar FMMs in Slovakia and the Netherlands received high rankings. The

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differences in overall ranking for similar FMMs may depend on differences in site conditions in the CSAs and differences in the expert judgements.

In conclusion, it is not possible on the basis of this analysis to undisputably say that one FMM is much better than other FMMs with regard to climate change mitigation effects. However, because short rotation coppice forestry combines low carbon storage in the stand with low substitution effects, these FMMs probably are less suitable if mitigating climate change is a major aim. Another general conclusion may be that FMMs that combine high growth and long-lived products, such as oak forestry in Germany, may be among the top FMMs for mitigating climate change. However, it is important to note that high climate change mitigation effects with this FMM is only possible on highly productive sites. If fertility is lower, the oak-FMM will suffer from low productivity compared to many conifer species.

1.2.3. Cultural

Outcome of the ranking of cultural values shows that they are connected to tree species and rotation period and not primary with silviculture system used in the different FMMs. But as there are correlations between FMM and rotation period, thinning program and tree species it is difficult to separate the effects from different factors.

In Ireland lowest values were obtained for clearfelling systems of conifers in pure or mixed stands but also nature consideration connected to open areas had low values. For Lithuania there are not very big differences but all FMMs for coniferous have lower cultural values than FMMs for broadleaves. For Sweden the trend is that coniferous and short rotations decrease the cultural values. Long rotation that is applied for oak have high values and also the stands with management for nature values.

Cultural values can have more to do with the management than other factors. An example of this is Germany where the cultural values have more to do with management dictated by the owner than tree species and rotation. Private owners focus on economics while State forest in Germany are obligated to multiple use by forest law. Cultural values for FMMs presented by Germany in Table 3.

In Italy small differences were reported, with highest cultural values for riparian forests. The small difference might be explained that only one management model is used and the size of CSAs is small.

Coppice system have in general low cultural values. Turkey and Portugal reported lower cultural value than other FMMs in respective country.

Stand variation, expressed as naturalness and complexity were low in some specially management stands, example Slovakia where the lowest value for cultural values was for FMM for water purification (Table 36). This was explained by the even and homogenous spruce stands that are characteristic for management for water purification. If special management has other aim the result can be high cultural values as in Sweden where management for high natural values also result in high ranking for cultural values (

Table 44).

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An interesting result is showed from the Netherlands, where cultural values differ between trees species or group of tree species but for each specie or group of specie are higher in production forest than in nature forests (**Fehler! Verweisquelle konnte nicht gefunden werden.**).

1.2.4. Regulatory services

Tree species seems to be the most important factor for risk for damages. Coniferous stands out with a higher risk for wind damages and fire than broadleaves. Compared to tree species, management models or other factors have a low impact. Only one partner, Lithuania, have added risk for diseases. With the experience of elm disease and the last decade experience of ash disease it can be discussed if all partners should include such severe events when describing risks.

In Germany the FMMs for coniferous stands have the highest risks and deciduous trees oak and beech lower risks. Spruce in clearcutting systems, with high risks for damages by bark beetles, wind and snow together give a higher risk than other tree species and FMMs. Spruce managed with selection systems have got a lover ranking of the risks, especially for wind and snow, than managed with clearfelling system. The risk for wind in that system was judged to be lower also compared with pine in shelterwood system (Table 5).

Lodgepole pine stands in the Irish CSA are not thinned and this have reduced the risk for winddamages. The risk is higher for other coniferous, mainly Sitka spruce, due to thinning and the fact that they normally reach a larger tree height then lodgepole pine. For the conifers risk for fire are highest in t*he thicket stage* and becomes lower when stands are older, Table 9.

In the Netherlands, the ranking was done regarding risks for wind damages and fire. There was a clear difference between broadleaves and coniferous, with a higher risk for damages with coniferous than for broadleaves. No difference between natural forests and production forests were reported (**Fehler! Verweisquelle konnte nicht gefunden werden.**).

1.2.5. Water

As for several other ES, assessment of protection of water quality, water availability, flooding and erosion is difficult to do at this preliminary stage of the project. An additional problem regarding water related issues is that none of the DSSs include direct modeling of water. Instead, development of the forest stand has to be used as an indicator for the FMMs effect on this ecosystem service. However, in some CSAs available DSSs will be further developed to more directly handle e.g. water quality.

Overall, FMMs containing broadleaves have been ranked higher that conifer dominated FMMs. The reason for this is two-fold. Firstly, conifer stands produce higher concentrations of dissolved organic carbon (DOC) leading to higher levels of leakage and brownification. Secondly, since broadleaves often have longer rotations, the area in clearcuts will be lower than for conifers resulting in reduced runoff and risk for erosion.

Undisturbed FMMs generally have a high ranking for water related ecosystem services. The continuous cover of trees reduces the risk for runoff and erosion. In addition, not harvesting these areas eliminate the negative effect on water quality by soil-damage caused harvesting machines. However, unmanaged broadleaved forests rank higher than unmanaged conifer forests.

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Not all FMMs are exchangeable and should therefore be compared with caution. Oak forests ranked high for water in Sweden whereas Scots pine forests received low ranking. However, it is not practically possible to grow oak on the poor, dry sites where Scots pine is dominating making the comparisons between these two FMMs questionable.

The Irish CSA contains a FMM specifically designed to buffer watercources from human land-use management interventions. Also, the Slovakian CSA has a FMM designed to protect water from leakage of nutrients and water protection is an important part of the Italian FMM.

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