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European Network on Mixed Forests



OVERVIEW OF MIXED FORESTS IN FINLAND

EuMIXFOR COUNTRY REPORT



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- Upper circle: Natural Norway spruce – Scots pine mixture. Photo: www.arvometsa.fi;
- Middle circle: Planted Scots pine – silver birch stand with thinning yield. Photo: Lauri Valsta
- Bottom circle: Natural mixture of Scots pine and birch species. Photo: Sauli Valkonen

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OVERVIEW OF MIXED FORESTS IN FINLAND

EuMIXFOR Country Report

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1. Overview of forestry in Finland

Finland is a highly forested country in the boreal region. Land classified as forestry land amounts to 26.2 mill. ha (86% of land area) and the extent of productive forest land (with M.A.I $\geq 1 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$) is 20.3 mill. ha (67% of land area) (Finnish Statistical Yearbook of Forestry 2014). Approximately 70 % of forests have been naturally regenerated but most of them are actively managed (State of Europe's Forests 2015).

Finland's forests are climatically part of the boreal region which represents approximately one third of the global terrestrial carbon stocks (Pan et al. 2011). In Finland, natural (and managed) tree species occurrence mainly follows temperature, soil fertility, and soil type (mineral, peat) patterns (Kellomäki 2005). Available water has a smaller role. Peatlands cover 25% of forest land area (Finnish Statistical Yearbook of Forestry 2014).

The forest land classified by the 10 most common dominant tree species in Finland are in Table 1.

Table 1. Forest land area by dominant tree species in Finland in 2004-2008 (Korhonen ym. 2013).

Tree species	Forest area dominated, km ²	Proportion in total forest area, %
Scots pine (<i>P. sylvestris</i>)	150 095	66.7
Norway spruce (<i>P. Abies</i>)	50 022	22.2
Downy birch (<i>B. pubescens</i>)	17 997	8.0
Silver birch (<i>B. pendula</i>)	5 514	2.4
Aspen (<i>P. tremula</i>)	597	0.3
Gray alder (<i>A. incana</i>)	477	0.2
Common alder (<i>A. glutinosa</i>)	187	0.1
Larches (<i>Larch</i> sp.)	142	0.1
Lodgepole pine (<i>P. contorta</i>)	121	0.1

However, the proportions of harvest differ from the above. In 2014, the share of Scots pine was 39%, Norway spruce 33% and broadleaved trees 28% (Finnish Statistical Yearbook of Forestry 2014).

Table 2. Area of mixed forest (min. 25 % admixture) by dominant species in Finland in 2004-2008 (Korhonen et al. 2013).

Dominant species	Area, km ²	Proportion in total forest area, %
Scots pine	12 372	6.2
Norway spruce	8723	4.3
Broadleaved species	7380	3.7
Total	28 475	14.2

Based on the Finnish Statistical Yearbook of Forestry (2014), the average annual increment of stem wood varies from $7 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$ in Southern Finland down to $1.4 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$ in the northernmost part of the country. The total stem wood increment was 104 mill $\text{m}^3 \text{ yr}^{-1}$ based on the latest national forest inventory of 2009-2012. The stem wood drain in 2015 was 82 mill m^3 , i.e., 79% of increment. Harvested stem wood volume amounted to 68 mill m^3 whereas forest waste and natural mortality combined were 14 mill m^3 . The total stem wood volume is estimated as 2100 mill m^3 . The stem wood harvest contained 37% logs, 50% pulpwood and 13% energy wood. Main tree species proportions of harvest were 44% Scots pine, 35% Norway spruce and 21% broadleaved species.

Forest area, growth conditions, growing stock, species composition, ownership, management patterns, utilization of forest resources in ecosystem service classification

Most of Finland's forests are owned by the 632 000 non-industrial, private owners. Their share is 53% of forest land area, 71% of growing stock on land for forestry, and 81% of industrial roundwood supply (Finnish Statistical Yearbook of Forestry 2014). Hence, the wood supply from private forests forms the basis for the forest industry. The roundwood market is composed of the private owners on the one side and three global, Finland based timber companies as well as several tens of smaller companies on the other side.

The goals of the non-industrial, private owners in Finland have in 1999 and 2009. The largest groups are multi-objective and recreational although economy-oriented goals have gained more popularity over the 10-year period (Table 3). Petäjistö and Matala (2015) observed a similar change from 2001 to 2014. Compared to more urbanized European countries, the forest owners in Finland seem to significantly appreciate forest-based income. The income based on selling standing timber was 2 billion euros in 2015, which amounts to approximately 3000 euros per owner (about 6000 euros per forest estate). A large proportion of forest owners work in their forests. For example, 56 % of tree planting and 66 % of young stand tending was performed by the owners in 2004-2008 (Hänninen et al. 2011).

Table 3. Finnish non-industrial private forest owners according to objectives (Hänninen et al. 2011).

Owner group by objectives	1999 percentages		2009 percentages	
	# of owners	forest area	# of owners	forest area
Multi-objective	34	47	30	40
Recreational	25	16	24	17
Forest income centered	18	18	20	17
Economic security	13	12	16	20
Undecided	10	7	10	6

The recreational use of all forests in Finland is common, excluding strict nature reserves. Forest access is facilitated by the so called "everyman's rights" by which entering the forest as well as picking berries and mushrooms is unlimited. The dense forest road network, 1650 m/km² in Southern Finland (Uotila and Viitala 2000) is predominantly open access, as well.

Since 1886, Finland has had forest laws with the purpose of securing timber availability by maintaining forest yields. The main regulation has concerned the requirement of regeneration in harvested areas while, in the latter half of the 20th century, there was a period with more stringent regulation, controlling the types and intensities of thinnings and regeneration methods. Starting in the 1960's, several policy programmes have supported investments into regenerating poorly stocked areas, ditching peatlands, building forest roads, fertilizing forests, and supporting biodiversity. Informational assistance has been provided by, e.g., lower cost forest management plans and guidelines for forest management (Tapio 2017).

2. Mixed forests dynamics and functioning in relation to ecosystem services and climate change

2.1. Basics of mixtures in Finland

The Finnish forests are predominantly managed as even-aged stands, applying rotation forest management with rotation lengths of 40-120 years. Artificial and natural regeneration are approximately equally common, mainly based on regeneration site properties (Korhonen et al. 2013, p. 491). Soil preparation was applied on approximately 80% of the regeneration area (Korhonen et al. 2013, p. 506). That results in wide availability of birch sp. seedlings and downy birch sprouts in areas regenerated for conifers. An important observation is that in most regeneration areas an admixture of broadleaved trees is, therefore, available for adopting a mixed-species stand structure. However, the higher commercial value of conifer species in Finland has led to management realizations where the resulting sapling stand is almost a pure conifer stand in most cases (only 14.2. % mixed species stands, Table 2). Reasons for this development could be goals to simplify cleaning work supervision and to divert ungulate browsers.

Due to the limited number of common tree species in Finland, there are four major kinds of mixtures:

1. Scots pine + Silver birch or Downy birch
2. Norway spruce + Silver birch or Downy birch
3. Scots pine + Norway spruce
4. Scots pine + Norway spruce + Silver birch or Downy birch

2.2. Scots pine + Silver birch or Downy birch mixtures

Scots pine and both of the common birch species in Finland are pioneer species that readily occupy open areas. In practice, most of regeneration areas for Scots pine have soil preparation which results in abundant natural regeneration of birch species. The shares of silver birch and downy birch largely depend on soil type: silver birch requires well drained mineral soil whereas downy birch can adapt to less aerated, moist or wet soils (Kellomäki 2005, p. 80). Part of downy birch seedlings are sprouts from stumps of trees that have occupied the site before regeneration.

Although all of the species in this mixture are pioneering species, there are differences in the early growth rate birches typically having a more rapid height growth. This leads to birches often overtopping Scots pines unless the stand is partially cleaned and most rapidly growing birches removed (Mielikäinen 1980). When the mixed stand ages, the height growth rates balance and at later age Scots pine becomes somewhat dominating.

2.3. Norway spruce + Silver birch or Downy birch mixtures

In natural succession, Norway spruce and birch mixtures exist as a temporary setting after which a pure spruce stand emerges (Kalela 1961, p. 208). A common situation also is that they coexist as a two-storied stand with birch as the upper story (Valkonen and Valsta 2001). Similarly to Scots pine – birch mixtures, the birch species depends on the soil conditions.

After artificial regeneration, Norway spruce plantation easily obtain a birch admixture. When the amount of birch canopy cover is limited, it is possible to establish a rather even-aged mixture, although birch has a clear tendency to overtop as it has a faster early height growth rate (Mielikäinen 1985).

2.4. Scots pine + Norway spruce mixtures

These mixtures often exist as a result of one of them being planted and the other one being established naturally. Both species can exist in both roles, depending on site fertility, soil preparation, and adjacent stands providing

seed dispersal. The management of these mixtures is sensitive to site fertility as there is a rather narrow range of fertility that is optimal for both of the species.

2.5. Scots pine + Norway spruce + Silver birch or Downy birch mixtures

The succession and management of this type of mixture is similar to those described in the above.

2.6. Continuous cover mixtures

Uneven-aged management of mixtures in Finland is challenging as there are no shade-tolerant domestic tree species and only one semi-shade-tolerant (Norway spruce). That constraints natural regeneration as the stocking has to be low enough for the domestic species to regenerate (Eerikäinen et al. 2014). The required lower stocking makes the sites vulnerable to excess grass and brush growth. A more common approach to management therefore is an extended rotation of stands that have some features of uneven-aged structure but are unable to sustain permanent continuous cover.

When evaluating the importance of uneven-aged management for different ecosystem service offerings one should also take into account the structure of Finland's forests. The average size of individual forest stands is approximately 1.2 hectares (Parviainen et al. 2009, p. 7). This implies that the area of stand boundaries is significant and provides biotopes similar to mixed species or mixed age forests.

2.7. Mixed forests as providers of ecosystem services

Mixed forests in Finland are capable of providing various ecosystem services. Observations are listed in Appendix. As for provisioning services, mixed forests have significant potential but it is only realized when forests are managed in a professional way. Regulating services are more easily provided as long as the proportions of species are maintained at adequate levels. For cultural services, mixed forests are not always superior in terms of recreational use. Supporting services have been and may become important for preventing a rise of pH but air borne acidification has somewhat reduced over the recent decades (Ruoho-Airola et al. 2014).

3. Adaptive management of mixed forests

Finnish forest legislation has two main objectives: maintaining forest cover (adequate stocking) and uphold biodiversity in forests. The revised Forest Act entered into force in 2014 (Forest Act 2013). Forest cover is maintained by regulations on regeneration and minimum stocking. There are no rules about mixed forests in particular but the selection of tree species in regeneration is constrained into 14 named species.

Best practice guidelines for silviculture (Tapio 2017) have been created in order to provide assistance to forest owners, timber companies and other forestry actors. For example, in stumpage sales it is assumed that the guidelines will be followed by logging contractors unless other agreements have been made. Birch admixture in conifer stands is recommended in several places of the guidelines. However, no exact recommendations on the amount of admixture (such as % stocking) is provided. Additionally, broadleaved admixture that is overtopping the conifers is recommended to be removed, unless it is the case of a two-storied stand. In general, an admixture that is not significantly effecting the main species is presented as desirable due to scenic, biodiversity, game management and pest reasons.

Finnish research on mixed forests suggests that, basically, a birch admixture is desirable from yield and economic points of view. Scots pine-silver birch mixtures maximizing yield and net revenues have a 20-40% share of birch at young and medium ages (up to 50 years) after which the birches should be gradually thinned away (Mielikäinen 1980, Valsta 1986). This strategy for mixture provided 0-10 % higher returns compared to

a pure stand. Similar results were obtained for Norway spruce-silver birch stands (Mielikäinen 1985, Valsta 1988, Matthies and Valsta 2016).

Simulations with a climate-sensitive forest model predict that the share of Norway spruce will decline significantly due to occasional drought period and increased mortality (Kellomäki et al. 2008). That would imply that spruce stands should have a sizeable mixture other species to hedge these risks. Concerning Norway spruce – Silver birch mixtures, Matthies and Valsta (2016) found that the spruce component has a higher storage of carbon. However, when albedo impacts and yield effects are also accounted for, and admixture of at least 10-30% birch was optimal in several parameter value combinations.

4. Establishment and tending of new mixed stands

In the Finnish conditions, mixed stands need to be established at regeneration because even-aged management is the dominant method. To reduce competition by ground vegetation and sprouting, a combination of soil preparation and cleaning is widely applied at regeneration. The planted seedlings attain faster growth and the competing vegetation is slowed down. All this works to the benefit of getting naturally pioneering tree species on regeneration sites. Admixture by those species is easily obtained and a mixed stand is only a matter of letting suitable seedlings grow.

Due to the faster early growth rate by birch species, their development typically needs to be slowed down to end up with a uniform canopy layer (Tapio 2017). Because Scots pine and Norway spruce are widely planted, there is no problem in securing ample representation of these conifers in the forest. Contrary, several less frequent broadleaved trees, such as aspen, alders and willows are often underrepresented in forests (Korhonen et al. 2013). The same applies to local oak, maple, ash, elms and lime which are at the boundary of their natural (and climatically feasible) range.

6. Conclusions

Common number of different mixtures is small, due to only 4 tree species widely available in Finnish forests. Several other species can be grown but because of the Finnish climate they are at their boundaries of range, their growth rates and economic returns are lower than the four main species.

Soil preparation enables easy creation of mixtures during regeneration so that birch admixture is widely available for planted conifer stands. However, it is common that the broadleaved admixture is almost entirely removed during young stand management. This is demonstrated by the fact that mixed forests only occupy 14% of forest area (Korhonen et al. 2013).

With proper management, birch-conifer mixtures have greater yield and better economics, and they provide improved risk management against biological and economic uncertainty. This management is based on non-constant proportions of tree species over the rotation. The competitive advantages of different species change over time and this should be taken into account when managing mixed forests. That also means decisions that are based on more accurate information about stand conditions and better knowledge of the future development of different stand structures.

7. References

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8. Appendix

Finnish studies of the comparative impact of mixtures and pure stands upon the ecosystem services provided by forests. Nomenclature for and typology of ecosystem services follows the framework used in the Woodlands chapter of the UK National Ecosystem Assessment (Quine et al., 2011 – Table 8.10)

Ecosystem service	Impact of mixtures	References
<i>Provisioning services</i>		
Crops, livestock and fisheries including NTFPs	No studies directly related to this aspect.	
Trees for timber	Under proper management, 0-10% increase in yield in conifer stands.	Mielikäinen 1980, 1985, Valsta 1986, 1988, Matthies and Valsta 2016
Trees for biofuel and/or woodfuel	Young stand thinning provides additional energy wood.	
Water supply	No studies directly related to this aspect.	
<i>Regulating services</i>		
Climate - Avoidance of climate stress.	Enhanced hedging for mortality.	Kellomäki et al. 2008
Climate - Carbon sequestration	Pure conifer stands offer highest carbon stocks.	Matthies and Valsta 2016
Hazard - Soil protection.	No studies directly related to this aspect.	
Hazard - Flood and water protection.	No studies directly related to this aspect.	
Disease and pests	No studies directly related to this aspect.	
Detoxification and purification - Water quality.	No studies directly related to this aspect.	
Detoxification and purification - Soil quality.	No studies directly related to this aspect.	

Ecosystem service	Impact of mixtures	References
<i>Regulating services (Continued)</i>		
Detoxification and purification - Air quality and noise pollution.	No studies directly related to this aspect.	
Pollination	No studies directly related to this aspect.	
<i>Cultural services</i>		
Wild species diversity - flora	No studies directly related to this aspect.	
Wild species diversity - fauna	No studies directly related to this aspect.	
Wild species diversity - invertebrates	No studies directly related to this aspect.	
Environmental settings - Amenity	No studies directly related to this aspect.	
Environmental settings - Recreation	No studies directly related to this aspect.	
<i>Supporting services</i>		
Soil formation, nutrient cycling, water cycling, oxygen production		
Biodiversity	Broadleaved considered to improve habitat diversity.	Matthies et al. 2016

