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Three scenarios for tree species composition and stand age in new and permanent forest areas: A case study of Latvia

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Abstract: Land abandonment and the emergence of new forest areas create novel dynamics for forest ecosystems and landscapes. Modelling is often used to forecast tree species composition, age group distribution and spatial patterns in the future. The aim of this study was to develop three scenarios for changes in tree species composition, stand age distribution and spatial patterns of new forest areas and permanent forests using Latvia as a case study. We selected 19 study areas of the size 10 km × 10 km to sample the variety of forest cover patterns, tree species, and stand age. Using GIS tools, we developed three scenarios: baseline, commercial and conservation. Results showed that the conservation scenario resulted in the most even-aged group distribution. Scenarios predicted the increase of *Picea abies* area (reaching 29.3% in permanent forests and even 45.7% in new forests) and the reduction of *Pinus sylvestris* in most cases. Changes in the median patch area were the best indicator for evaluation of different scenarios with the largest patches of new forest areas for the conservation scenario (1.92 ± 1.23 ha). The existing structural and compositional integrity of sampled forest landscapes was best retained under the baseline and conservation scenarios, while the commercial scenario indicated more fragmented forest landscapes in the future.

Keywords: forest harvesting; forest management; geographic information systems; landscape metrics

Forests are an indispensable part of the biosphere, providing crucial services to humankind (Millennium Ecosystem Assessment 2005). The profound significance of forests ties into almost every facet of human societies, from survival to business activity. Processes of farmland abandonment and subsequent afforestation of these areas create new dynamics of forest change. These processes have occurred worldwide, however, numerous papers have focused on changes in Europe, especially in Eastern Europe (Kuemmerle et al. 2011; Alix-Garcia et al. 2012; Alcantara et al. 2013). The decades-long process of farmland abandonment has resulted in the emergence of considerable new forest areas (Sitzia et al. 2010; Ruskule et al. 2012; Vinogradovs et al. 2018).

These new forest areas are understudied both from the landscape ecological perspective and the perspective of sustainable forest management. Spontaneous afforestation or forest regeneration changes

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the ecological functioning of landscapes (Elmarsdottir et al. 2008) and full effects of these changes are still unknown. Since these forest areas are a new phenomenon, there is little data on their management (Hazarika et al. 2021). Afforestation is closely linked to land ownership (Eggertsson et al. 2008; Schaich, Plieninger 2013). Patterns of forest land ownership influence management decisions of small private owners (Hirsch, Schmithüsen 2010; Quiroga et al. 2019). Specific management challenges include remoteness of forest holdings, the lack of management infrastructure, small size of forest holdings and the lack of knowledge on forestry issues (Haugen et al. 2016; Rizzo et al. 2019). The consideration of spatial patterns in the process of management planning is still challenging and rarely implemented (Gustafson et al. 2006; Gärtner et al. 2008).

Spatially explicit modelling of forest landscapes has been developing rapidly over the last two decades (He 2008; He et al. 2011). Ready-to-use forest landscape models, for instance LANDIS (Mladenoff 2004; Scheller et al. 2007) have been developed and released to the public. Scenario development is a common method to forecast probable future states of forest landscapes (Bishop et al. 2007; Carlsson et al. 2015; Heinonen et al. 2017; Aggestam, Wolfslehner 2018). This primarily includes forest characteristics such as tree species composition, stand age, disturbances, and spatial patterns. The scenario development approach is often used in landscape ecological planning (Leitao, Ahern 2002). The advantage of this approach is the ability to present simulated future states both visually – as maps, and quantitatively – using statistics.

The composition and spatial configuration of tree species in forested areas comprise two main aspects of spatial structure in forest-dominated landscapes (Turner 1989; Gustafson 1998). Fundamental spatial pattern metrics such as area proportion, patch size and the number of patches directly relate to the composition of land cover types; measures of patch shape and spatial isolation relates to the spatial configuration (Lausch, Herzog 2002; Schindler et al. 2013). Such basic metrics of spatial patterns are easy to communicate and do not require additional parametrisation (Uuemaa et al. 2009).

Our study aimed to develop and compare three possible future scenarios – baseline, commercial and conservation – for new forest areas 50 years into the future, using Latvia as a case study. The objectives of this study were: (*i*) to extract the characteristics of forest compartments from the State Forest Register database; (*ii*) to define three scenarios for tree species composition and stand age 50 years into the future; (*iii*) to simulate future tree species, stand age and spatial patterns (spatial distributions of forest stands); and *(iv)* to evaluate and compare the scenarios using calculated landscape-level characteristics. In this study, we used 19 sample areas to represent the variety of species and age patterns across the country.

MATERIAL AND METHODS

Study area. The study area was the entire territory of Latvia (Figure 1). Located in North-Eastern Europe on the eastern coast of the Baltic Sea, Latvia falls into the hemi-boreal biome (Sjörs 1963), hav-

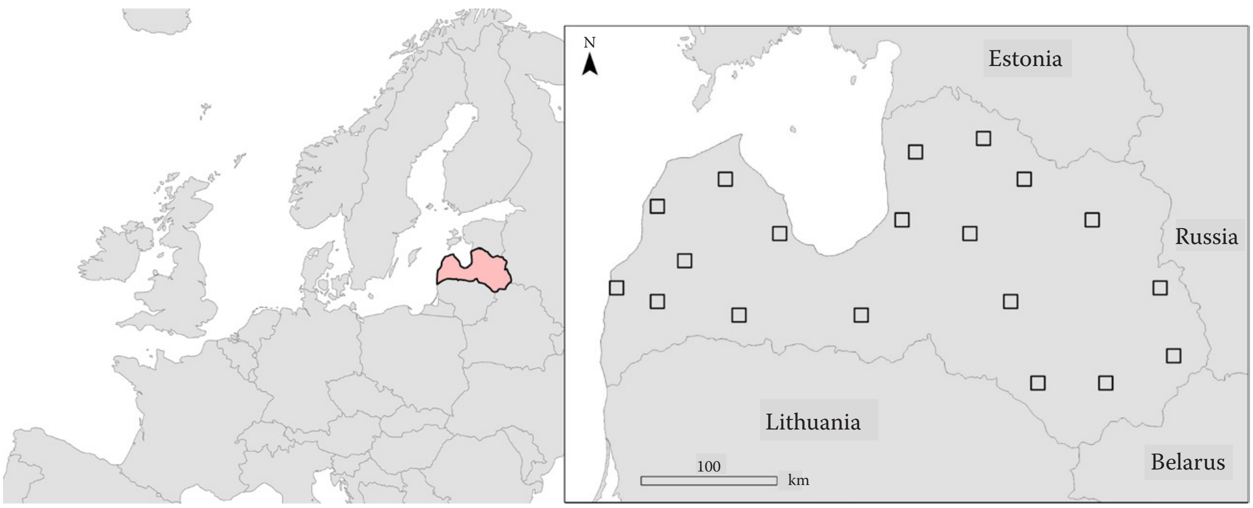

Figure 1. The location of Latvia and the 19 study areas

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ing elements of both boreal and nemoral biomes. Latvia's forest cover is high, reaching 54% (Statistical Inventory of Forests 2018), with forested areas occurring quite evenly across the country. Latvia's forests are mostly composed of mixed stands with the dominance of four major tree species: Scots pine (*Pinus sylvestris* L.), silver birch (*Betula pendula* Roth), downy birch (*Betula pubescens* Ehrh.) and Norway spruce (*Picea abies* Karst.) – they comprise 89% of Latvia's forest area (Statistical Inventory of Forests 2018). Other tree species such as European aspen, black alder and pedunculate oak are found mainly mixed with the aforementioned dominant species.

48% of the forest area in Latvia is state-owned and is managed by JSC Latvijas Valsts Meži. Non-state forest owners include private family owners, commercial forestry companies, churches, organisations, and individuals. The majority of private forest owners' holding size is very small – around 7.5 ha (Statistical Inventory of Forests 2018).

The climate in Latvia is moderate; the western part of the country has maritime influences with shorter and milder winters and the eastern part has a more continental climate. The mean January temperature is –5 °C and reaches +16 °C in July. Annual precipitation in Latvia ranges from 550 to 850 mm, and the amount of precipitation exceeds evapotranspiration (Briede 2018). The elevation in the territory of Latvia ranges from 0 m a.s.l. to 311 m a.s.l. and the terrain consists of lowland plains, undulated plains, and glacial uplands.

This study used simple random sampling to select new and permanent forest areas in Latvia using 19 regular sample cells sized 10 km × 10 km. Only cells with > 20% of forest cover were considered for selection. We selected 100 km^2 grid cell size as a compromise for representation of individual landscapes rather than entire regions. We used the term 'permanent forest' to denote areas which were forested during the time period (1967–2017) relevant in defining 'new forest' areas (established during the above-mentioned period). Our study areas comprise 3% of the entire territory of Latvia, and the selected cells capture the variety of forest cover for both new forest areas and permanent forests.

Table 1 shows that forest cover proportion in sampled cells varied greatly – from 25.4% to 80.2% with the median value of 53 ± 13.5%. As parts of this forest cover proportion, new forest areas make up 1.3% to 10.8%. Generally, sampled plots with the highest proportion of forest cover were characteristic of broader regions with large tracts of forest or forest-dominated regions. Forest ownership patterns also vary greatly between studied areas. The proportion of public forest areas ranged from 0.8% to 67.3% with the median value of 38.0 ± 16.4%.

Data sources. Scenario development was based on the Latvian State Forest Register (SFR) data for 2017. SFR is a geospatial database, containing detailed information on stand characteristics [age, dominant tree species, height, standing volume, type of management actions (tending operations and silvicultural systems), protection status etc.]. The smallest unit in SFR data is the forest compartment. New forest areas were delineated using the analysis of historical Corona KH-4B (1967–1972) and modern Landsat 8 (2017) remote sensing imagery spanning over a 50-year period. Structure-from-Motion photogrammetric processing in Agisoft Metashape (Version 1.6, 2020) was used to rectify the Corona imagery. Object-Based Image Analysis using spectral thresholds was used for the delineation of forested areas in eCognition Developer (Version 9.0, 2014) for both historical and modern imagery. For full workflow see Rendenieks et al. (2020). It is important to note that these new forest areas did not include forest gain after clearcuts or natural disturbances. Delineated forest gain was on lands without forest cover in 1967.

Table 1. General characteristics of sampled areas (*n* = 19)

Characteristics	Min.	Max.	Median	SD
	(%)			
Forest cover in 2017	25.4	80.2	53.0	13.5
Permanent forest area	23.5	74.1	49.5	13.3
New forest area	1.3	10.8	4.4	2.2
Share of public forests	0.8	67.3	38.0	16.4
Proportion of area with the prohibition of final felling	2.1	26.8	11.5	5.0

SD – standard deviation

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Table 2. Tree species parameters (Cabinet of Ministers' regulation No. 935, 2012)

Tree species	Rotation age (years)*	Min. *DBH* for final felling (cm)*
Pinus sylvestris	101 and older	27–39
Picea abies	81 and older	27–31
Betula spp.	71 and older	22–31
Alnus glutinosa	71 and older	–
Alnus incana	–	–
Populus tremula	41 and older	–
Quercus robur	101 and older	–
Fraxinus excelsior	81 and older	–
Tilia cordata	81 and older	–

* depending on stand productivity class, lowest value given; *DBH* – diameter at breast height

We used ancillary data from JSC Latvian State Forests to identify the ownership of forest compartments (Latvijas Valsts Meži 2021) and used open-source data from the Nature Conservation Board to determine the conservation status of forest stands (Dabas Aizsardzības Pārvalde 2022).

Methods and workflow. We selected 19 evenly distributed sample areas in Latvia using map grid cells with the size of 10 km × 10 km. Sample areas were named after the nearest major settlement (Adazi, Aglona, Aizpute, Cesis, Dagda, Dundaga, Engure, Gulbene, Iecava, Ilukste, Kuldiga, Liepaja, Limbazi, Ludza, Plavinas, Saldus, Seda, Smiltene, Ventspils). SFR data was then clipped for each sample area separately. We used geographic information systems (GIS) tools in ArcMap (Version 10.8, 2020) (ESRI 2020) to develop scenarios of forest landscape change. This included multiple data processing tools for filtering, subsetting, clipping datasets as well as multi-argument queries for attribute data to select forest compartments for each tree species at each age class separately for each scenario to recalculate the initial attribute values.

We chose a simple, quantitative, spatially explicit approach to simulating forest landscapes – the approach commonly used to simulate management outcomes (Hoogstra-Klein et al. 2017). A 50-year time span was chosen for the simulation of tree species composition and age structure due to the challenging nature of predicting multi-actor decisions, including chance events and changes in policy for periods longer than 100 years (Table 2).

We developed three scenarios (Table 3) for all 19 sampled forest landscapes. Each of the three scenarios represents a distinctive policy trajectory in a generalised way. Tree growth for each species was calculated using formulas from Liepa (1996).

Baseline is the first scenario, which assumes that during the simulated period, no significant changes in legal regulations and management practices are

Table 3. The assumptions for three development scenarios

Name	Short description of assumptions
Baseline scenario	This scenario assumes that no significant changes take place regarding both legal regulations of forest management actions and established policies of forest sector actors.
Commercial scenario	The demand for timber remains high and timber prices are stable or rising. This is combined with reducing the age and minimum *DBH*, which results in shorter rotations. In this scenario, the area of protected forests remains unchanged, but some seasonal (bird nesting period) and landscape protection restrictions are lifted.
Conservation scenario	Under this scenario, the level of forest protection is raised substantially through the creation of new protected areas (+20% in terms of area), introducing more seasonal (bird nesting period) restrictions and prohibiting the felling of overmature stands. This results in the reduction of forest area without any restrictions for harvesting.

DBH – diameter at breast height

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taking place, which could impact specific management actions (regulation for pre-commercial and commercial thinning, final felling, restrictions to forest land conversions etc.). Minimum requirements for final felling (Table 2) would remain unchanged. The clear-cut would remain the main regeneration method/silvicultural system. Harvest rates would follow the allowed volumes of final felling (Cabinet of Ministers' regulation No. 718, 2015), which would stay in place in state-owned forests. In private forests, harvest levels were expected to change with fluctuations in timber prices.

Commercial is the second scenario, which assumes high – stable or rising timber prices and the loosening of harvesting restrictions (minimum age for final felling, removing seasonal restrictions and maintaining the current area of protected forests). This would maximise timber production through the reduction of minimum felling age for the main commercial tree species (reduction by 20 years for *Pinus sylvestris* and by 10 years for *Picea abies*) and the reduction of minimum diameter at breast height (*DBH*) for final felling to 20 cm (the lowest value, for the most productive stands). The clear-cut would remain the main method for final felling. Relaxed requirements for stand regeneration after the final felling would also take place, extending the regeneration term to five years. This scenario would also soften the restrictions for changing target tree species, since it is currently limited to tree species 'characteristic to the growing conditions of each forest stand' (Law on Forests, 2000), but would still forbid the planting of alien tree species outside plantations. The relationship between timber prices generally depends on the type of forest ownership (Kangas et al. 2000), since harvesting volumes in public forests are fixed and fluctuate less with changing timber prices (Beķeris 2011). New forest areas are expected to be more likely to change target species, having negligible protection status and less restriction.

Conservation is the third scenario, which assumes a 20% increase in protected areas (overall) and additional restrictions to commercial forest management, including the prohibition on the felling of overmature stands. Under this scenario, 'protected area' denotes a forest area with the prohibition of timber harvesting in the form of final felling. This would include a 10% area increase under current seasonal management restrictions during bird nesting in state-owned forests. In the case of this scenario, no harvesting is assumed to take place inside protected areas of any type during the modelling period. The conversion of forest stands and the change of target tree species was also considered to be limited to private forest lands. The outcome of this scenario will greatly depend on the initial proportion of forest under management restrictions inside each study area.

We measured simulated spatial patterns using selected basic landscape metrics: the number of patches (the count of separate forested areas of the same category), class area (the total area of each category), patch area (the median area of separate forested areas of the same category), shape index (the median value of the compactness index), and Euclidean nearest neighbour distance (the median shortest distance between forested areas of the same category). For further information see Cushman et al. (2008) and Uuemaa et al. (2009). For this, we converted vector source layers into categorical raster layers with a spatial resolution of 10 m. We calculated metric values using R package landscapemetrics (Hesselbarth et al. 2019). We used median values and standard deviations to characterise statistical distributions of calculated values.

RESULTS

Tree species composition. Notable changes were found in tree species composition in three development scenarios compared to the initial (2017) composition (Figure 2).

Firstly, *Alnus incana* area proportion decreased greatly under all scenarios, except for the conservation scenario in new forests, where it shrank from 19.8% to 14.6%. Under other scenarios, especially the commercial, it decreased even more. Under the commercial scenario, *Alnus incana* area proportion was 2.3% in permanent forests and 2.3% in new forests. *Pinus sylvestris* area proportion was found to vary from scenario to scenario as well: from the initial 26.8% in permanent forests and 12.8% in new forests, it decreased under all scenarios, except the conservation scenario in permanent forests (from 26.8% to 31.4%). The area proportion of *Picea abies* is considerable already in the initial state, reaching 20.9% and 25.8% in permanent and new forests, respectively. Under the Baseline scenario, the proportion of *Picea abies* increased by 2.4%, but in new forests – even by 10.9%. Under the commercial scenario, the proportion of *Picea abies* is even higher,

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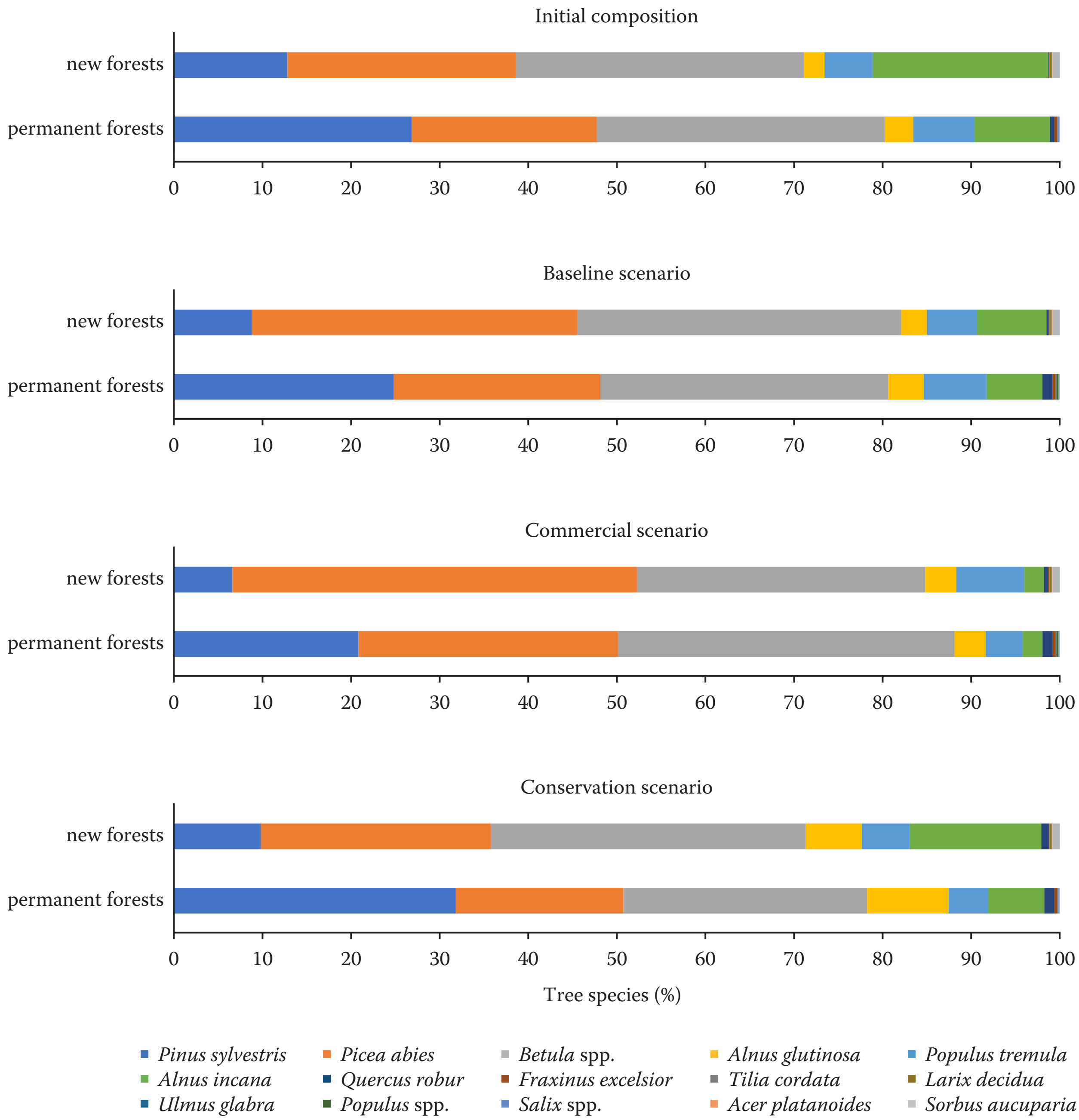

Figure 2. Tree species composition (initial and the three scenarios) in the 19 study areas in Latvia

reaching 29.3% in permanent forests and 45.7% in new forests. *Betula* spp. area proportion changed little between the three scenarios, with the greatest increase under the baseline (+4%) and the commercial (+5.5%) scenarios. *Alnus glutinosa* stands increased under the baseline (+0.8% in permanent forests and +0.6% in new forests) and the conservation (+6% in permanent forests and +3.9% in new forests) scenarios. The area proportion of *Quercus robur* increased marginally in all three scenarios compared to the initial composition.

Scenario modelling demonstrated that notable changes in stand age (Figure 3) distribution will take place under all three scenarios, but the most pronounced changes were found under the commercial and conservation scenarios. When analysed relative to the area occupied, *Picea abies* stands after 50 years under the baseline scenario will be mostly 31–70 years old. *Picea abies* is also prominent in the commercial scenario, especially in age groups 51–60 and 61–70. Under all three scenarios, very few *Picea abies* stands older than 100 years will re-

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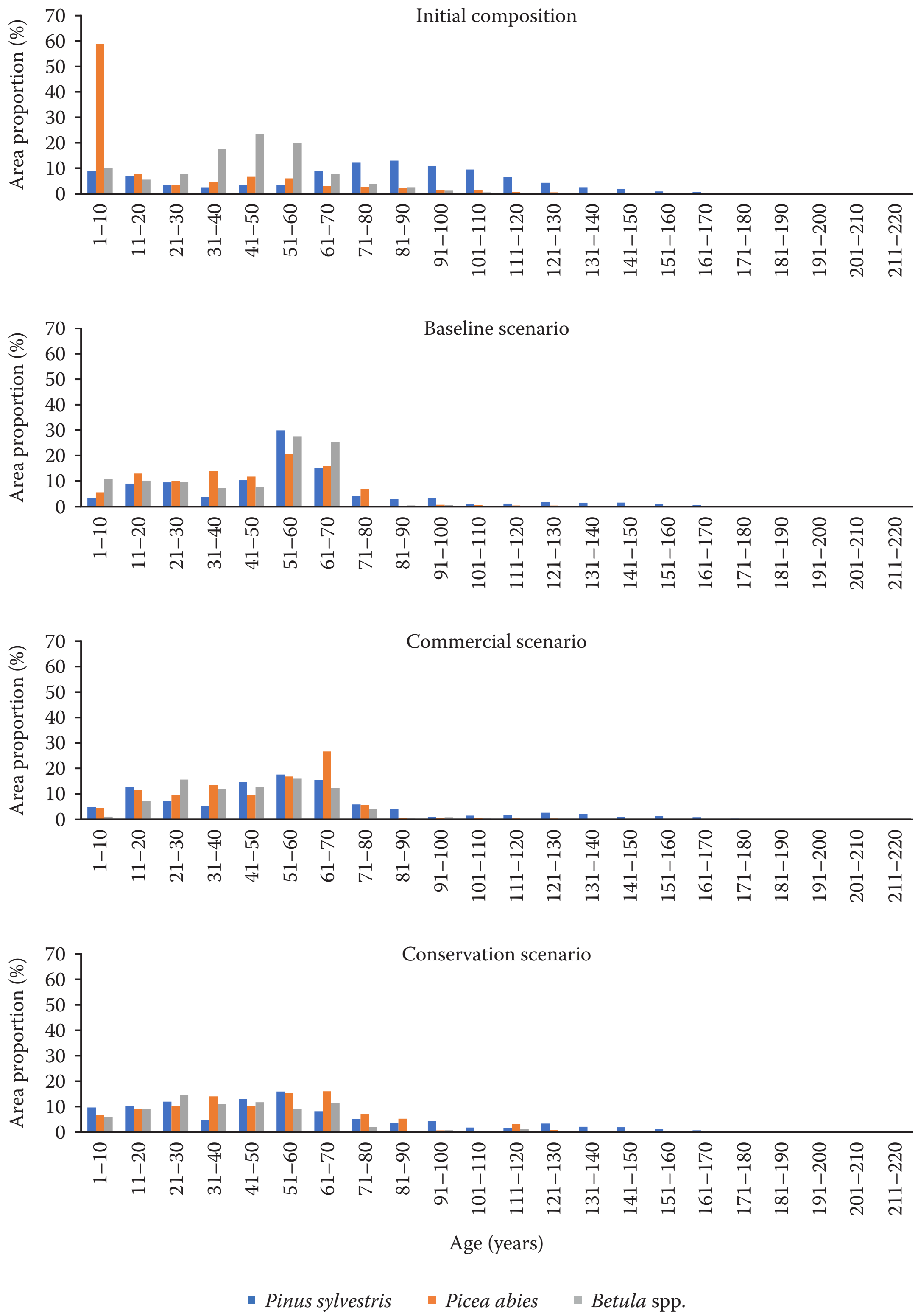

Figure 3. Stand age distributions (initial and the three scenarios) in the 19 study areas in Latvia

main. Under the baseline scenario, *Betula* spp. indicate a high proportion of stands aged 51–70 (close to the felling age), but this is less pronounced under the conservation scenario.

Pinus sylvestris stands indicate declines in younger age classes (1–10 and 11–20 years) but dominate by area after the age of 91. The baseline scenario predicts a high proportion (almost 30% of all *Pinus*

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Table 4. Differences in median spatial pattern characteristics of sampled areas (n = 19) between the baseline, commercial, and conservation scenarios

Metric	Type of forest	Baseline	Commercial	Conservation
Number of patches	permanent	224 ± 123	231 ± 199	219 ± 144
	new	229 ± 134	240 ± 117	182 ± 154
Total area (ha)	permanent	4 859 ± 1 304	4 911 ± 2 712	4 892 ± 2 115
	new	440 ± 223	401 ± 304	418 ± 275
Patch area (ha)	permanent	22.60 ± 20.00	18.50 ± 27.00	34.50 ± 41.00
	new	1.88 ± 1.10	1.19 ± 0.70	1.92 ± 1.23
Shape index	permanent	1.75 ± 0.48	1.72 ± 0.77	1.74 ± 0.99
	new	1.66 ± 0.53	1.69 ± 0.45	1.87 ± 0.66
ENN distance (m)	permanent	63.30 ± 26.00	126.50 ± 64.00	50.20 ± 58.00
	new	143.00 ± 43.00	191.00 ± 88.00	151.00 ± 67.00

ENN – Euclidean nearest neighbour; standard deviations are shown

sylvestris stands) at the age of 51–60. Under the conservation scenario, a higher proportion of overmature stands will be present – compared to the very low proportion of such stands in the other two scenarios.

Among all three developed scenarios, the conservation scenario resulted in the most even age group distribution. The baseline and commercial scenarios predicted relatively high proportions of stands at the felling age or close to it after 50 years.

Spatial patterns. The three developed scenarios resulted in different spatial patterns, captured by landscape metrics (Table 4). From the main compositional characteristics, the median number of new forest patches was the highest in the commercial scenario (240 ± 117) and the lowest in the conservation scenario (182 ± 154).

The median number of patches for permanent forest areas was very similar to new forests, except for the conservation scenario (219 ± 144 and 182 ± 154, respectively). Class area (the total area of each of the two forest cover types) varied negligibly between scenarios, both for new forest areas and permanent forests. However, the median patch area differed notably between scenarios. For new forest areas, the median patch area was the highest in the conservation (1.92 ± 1.23 ha) and the baseline scenarios (1.88 ± 1.10 ha). For permanent forest areas, the median patch area reached 34.5 ± 41 ha in the conservation scenario, 22.6 ± 20 ha in the baseline, and 18.5 ± 27 ha in the commercial scenarios.

Spatial configuration measures included median shape index and median Euclidean nearest neighbour (ENN) distance. For new forest areas, median shape index values were very similar between all three scenarios, ranging from 1.72 to 1.75, but we found higher dispersion for the conservation and commercial scenarios. For permanent forest areas, shape index values were lower, indicating generally simpler patch shapes, also with less variation compared to new forest areas. For new forest areas patch isolation (measured by median ENN distance), the lowest was in the baseline scenario (143 ± 43 m), but in permanent forest areas, the lowest isolation was in the conservation scenario (50.2 ± 58 m). Patch isolation values for new forest areas were overall higher compared to permanent forests due to their much smaller area proportion.

DISCUSSION

The sampling scheme chosen for this study was successful, because it captured well the wide variation of forest cover proportion, forest ownership and diversity of spatial patterns, as shown in Table 3. These three scenarios attempted to capture three distinct trajectories of forest management with many actors and stakeholders involved. This study did not attempt to make detailed predictions for the market, labour costs, inflation dynamics and other important factors, which were out of the scope of this study, but nevertheless are crucial for forecasting of this kind. Instead, we focused on simulated changes in basic stand-level charac-

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teristics which are reflected in SFR data and other quantitative records, as such databases are actually used in forest management planning.

Our results demonstrated that, under different development scenarios for forest management, it is necessary to include not only probable changes in stand age (as direct consequences of different management scenarios), but also the probability of changing the dominant tree species in particular compartments – either driven by commercial interest or due to natural, stand-replacing disturbance. Our results showed the reduction of *Pinus sylvestris* area under the baseline and commercial scenarios. We explain this outcome as the result of the continuation of existing trends in Latvian forests, where the area proportion of *Pinus sylvestris* shows a long-term decrease (Statistical Inventory of Forests 2018). The increase of *Picea abies* in basically all scenarios is not surprising, since it continues to be the main preferred species for timber production, despite the risks discussed below. The change of forestry target species from *Alnus incana* to *Picea abies* or *Betula* spp. is very common in Latvian private forests, so it was expected to take place mainly under the first two scenarios.

There are growing concerns for choosing *Picea abies* as target species due to the increased risk of bark beetle (Jonášová, Prach 2004) and wind damage (Samariks et al. 2020). The change in target tree species was predicted to occur more often under the commercial scenario, but it was assumed probable under the other two scenarios as well. Since our study covered only 50 years, medium-term responses to the risk of bark beetle invasions were not included in our simulation. Short-term responses would include preventive measures, such as sanitary cuts and pheromone traps; however, opting out of *Picea abies* as the main target species is not expected.

In modelling studies using forest management scenarios (for example Mohren 2003; Creutzburg et al. 2017), management scenarios are analysed specific to forest types and ownership types. The main contrast in our study is given to differences between new and permanent forest areas. Management trajectories for these two types depend mainly on the ownership – since the absolute majority of new forest areas were privately-owned. Our results showed that new forest areas are more dynamic – more likely to change target species, having negligible protection status and less restriction under all scenarios. This dynamism also includes the possibility of owner change.

The inclusion of spatial pattern measurements allowed us to quantitatively evaluate and compare simulated landscapes from a spatial perspective (Figure 4). Landscape metrics have been used in spatial planning, scenario development and decision support (James et al. 2007; Gärtner et al. 2008; Shooshtari, Gholamalifard 2015). From all the calculated pattern metrics, patch area was the most useful one since it indicated changes in the size for the most basic units of landscape pattern. The landscape patch is the essential element of every landscape (Forman, Godron 1981; Lausch, Herzog 2002). In our results, changes in the median patch area were the best indicator, discriminating the effects of different scenarios with the largest patches of new forest areas in the conservation scenario, and the smallest in the commercial scenario (see Table 4). With class area and the shape index conveying little information on differences in future trajectories in spatial patterns of forested landscapes, the median ENN distance was the other useful measure. It indicated the baseline and conservation scenarios as the best for reducing overall patch isolation for new forest areas, and to a lesser degree, it was the same for permanent forest areas. Our results also showed that interactions between elements of spatial pattern are complex and unexpected outcomes can arise.

As in the case of every modelling study, ours has serious limitations, as numerous important factors influencing the results were not included in this study. Firstly, climate factors were not considered, since it was out of the scope of this study. The impact of climate change on forestry is very hard to predict even in a much shorter period. Secondly, local growing conditions play an important role, but, unfortunately, we did not have access to a reliable, detailed dataset. The probability of natural disturbances is another important factor, which we could not include in this study. The introduction of adaptive management was not included in our simulations – this could be a response to the above-mentioned changes in climatic factors as well as increased natural disturbances. And, lastly, there are chance events, which are unpredictable and can change the trajectory of forest management in certain areas. Our simulation did not include chance events in any of our scenarios.

50 years is a relatively short period for modelling changes in tree species composition and age struc-

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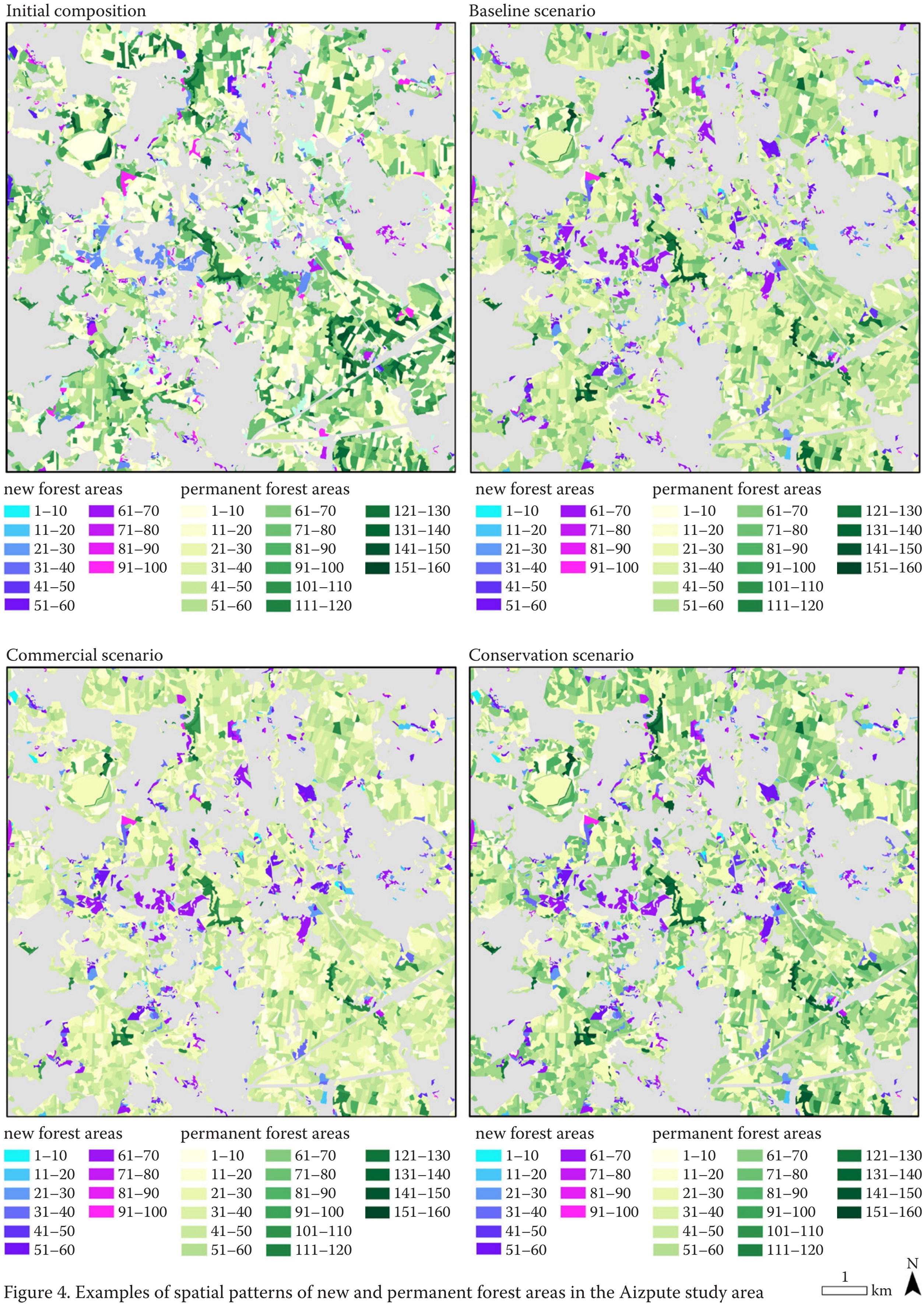

Figure 4. Examples of spatial patterns of new and permanent forest areas in the Aizpute study area

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ture (Scheller et al. 2007). However, due to several factors, a considerable amount of changes becomes visible. Firstly, new forest areas are very dynamic compared to permanent forest areas and thus are often a subject of radical management decisions like change of target species from *Alnus incana* (which can be felled at any age in Latvia) to a more commercially profitable one like *Picea abies* or *Betula* spp. Furthermore, the absolute majority of new forest areas are owned by small private owners, who often have little interest in forest management (Ruskule et al. 2013; Eggers et al. 2014) and thus are more likely to sell their holdings.

Forest management in Latvia is influenced by distinct spatial patterns of forest cover where permanent forest lands generally form large tracts, and emerging new forest areas form smaller patches – the result of spontaneous afforestation on previously non-forest lands (Boruks 2003; Ruskule et al. 2012; Rūsiņa et al. 2021). These large tracts are the main arena for commercial timber harvesting (Naumov et al. 2018), but holdings of small private owners are often adjacent to these tracts. Additionally, very small forest compartments (1.5–5 ha) are characteristic of the Baltic countries (Brukas, Weber 2009) and in many cases this factor inhibits forest management efforts for small private owners. The area proportion under protection is very low in privately-owned forests in Latvia, but, similar to current trends, interest in nature conservation for small private owners in Europe is growing (Tiebel et al. 2022).

CONCLUSION

This study demonstrated that scenario development can be a useful tool for the spatial modelling of forest-dominated landscapes. Our focus on the distinction between new and permanent forest areas added a new dimension to the spatial modelling and revealed that new forest areas, considering their properties like mean area, substrate type and spatial adjacencies, are generally more dynamic, heterogeneous and less predictable with higher variations for simulated characteristics. Over the 50-year period, new forest areas became more similar to the adjacent permanent forest areas in terms of tree species composition, age group distribution and spatial patterns. The existing structural and compositional integrity of sampled forest landscapes was best retained under the baseline and conservation scenarios, while the commercial scenario indicated more fragmented forest landscapes in the future.

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