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Spatial Patterns of the Old Stands in the North Vidzeme Biosphere Reserve

ZIGMĀRS RENDENIEKS* AND OĻĢERTS NIKODEMUS

University of Latvia, Faculty of Geography and Earth Sciences
Alberta str. 10, Riga, LV-1010, Latvia
E-mail: zigmars.rendenieks@lu.lv

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Abstract

The value of older forest for biodiversity conservation is thought to greater than younger forest, and therefore they need particular consideration in sustainable forestry planning. In Latvia, sustainable forest management is a primary goal set by the State Stock Company "Latvijas valsts meži". Landscape-level sustainability is also the goal for the North Vidzeme Biosphere Reserve (NVBR), which was chosen as a study area. We used stand age as a criterion for selection of stands of the common tree species – pine, birch, spruce, black alder, aspen, oak and ash. Forest inventory data from 2011 were used as the main source of information. This study utilized an analytical approach to the assessment of spatial patterns of mature and overmature stands. Overmature stands might be considered as having high potential value for conservation, thus promoting one of the biodiversity as one of key aspects for sustainable forest. Mature stands, which are those that have reached legal cutting age, represent a reserve for the overmature stands, thus ensuring integrity of biodiversity structures. The results showed various potential of mature forest to facilitate biodiversity in the nearest decades from the aspect of stand spatial pattern properties. From the forestry target species, overmature spruce and birch stands over time can be supplemented from the reserve of mature stands, but old aspen woodland was evaluated has having the least potential for continuity in both state and private forest.

Key words: overmature forest, landscape pattern, landscape metrics

Introduction

Latvia, like other countries in Europe, has undergone several phases of forest history, during which natural forest structure has been highly altered (Tērauds et al. 2011, Zunde 1999). Wide-scale forest harvesting has led to changes in the structure and species composition in forest across Fennoscandia and North America (Foster et al. 1998, Kouki et al. 2001, Östlund et al. 1997). Current forest spatial structure in Latvia reflects historical disturbances, management policy and actions (Tērauds 2011). For example, due to overgrowing of agricultural lands, and management promoting mixed forest stands in the Soviet period, proportion of coniferous stands dropped from 78.2% to 60.1%, and accordingly the area of deciduous forest increased (Laiviņš 1998). Currently, forests cover 54.7% of the total area that is twice more than in the 1930s (Latvijas Statistika 2011). Of the forest area, only 3.1% is protected from all types of wood removal (VMD 2011a), which is less than the average of 5% in Europe (MCPFE 2011, Wallenius et al. 2010).

Since wood is regarded as valuable natural resource, forest management has suppressed natural disturbances like fire and pests, which are important in maintaining the structure of natural forest (Frelich 2002, Spence 2001) and biodiversity (Kimmins 1987). In managed forest, age structure reflects timber management strategy, which generally simplifies the forest age structure (Kuuluvainen 2002) resulting in more uniform age distributions up to the rotation age, followed by a sharp decline in older age classes (Fall et al. 2004).

Old stands ('old' here denotes stands with dominant species that have reached the overmature phase) potentially provide critical habitat for rare and endangered species (Berg et al. 1994) mostly from primitive organism groups – fungi, bryophytes and lichens (Angelstam et al. 2005). Old forest areas have declined in many European countries due to introduction of stand-replacing clear-cutting methods (Rolstad et al. 2009) and private ownership can result in small and isolated patches (Kurttila et al. 2002). In Latvia, up to the year 2005, 19% of state-owned and 7% of private or municipality-owned forest was above the cutting age (Angelstam et al. 2005).

Maintenance and restoration of forest biodiversity is still the main concern for many countries (Angelstam and Andersson 2001, Hunter 1999, Spence 2001) and the relevant information about habitat properties is needed to reach these goals (Noss 1999). Since industrial forest exploitation in Latvia has a shorter history than in, for example, Scandinavia, numerous threatened species still have large populations in Latvia (Angelstam et al. 2005) offering a pro-active opportunity to conserve biological and landscape values through sustainable forest planning. Designation of woodland key habitats is one of the ways of conserving existing diversity (Ikauniece et al. 2012, Spence 2001). Clarifying forest areas with biodiversity potential would be the next step towards sustainable forest management.

Managed forest in Latvia after 2008 experienced a sharp increase in annual cutting volume (VMD 2010) due to the economic crisis. Since 2009 there was also a change in tactics of forestry planning by switching from irregular planning of cuttings to a block cutting method in state-owned forest (VMD 2011b), therefore impacting forest spatial structure, in a different way as in private forest.

Quantitative indices have been often used for assessment of spatial patterns of old forest (Brotons et al. 2003, Mladenoff et al. 1993, Ripple et al. 2000, Spies et al. 1994). Landscape metrics are indicators for quantifying the specific spatial characteristics of patches, classes of patches, or entire landscape mosaics (McGarigal 2002). These indices characterize different aspects of spatial patterns in landscapes. Metrics are more suitable analysis of remnant patches than for describing matrix (Lofman and Kuoki 2001). The opportunity to calculate statistical indicators like landscape metrics has provided researchers with a wealth of information, but careful consideration is needed on how many components of landscape structure are relevant and which metrics should be used to represent those components (Cushman et al. 2008). Studies concerning the particular landscape-scale pattern characteristics like patch size and isolation evidence their relation to abundance of wildlife species like wild hog (Gaines et al. 2005), elk (Stubblefield et al. 2006) and gray wolves (Mladenoff et al. 1995).

In this study, spatial properties of state and non-state forest were examined in relation to management differences. The aim of the study was to assess the spatial pattern of overmature and mature forest stands in managed forest landscape of North Vidzeme Biosphere Reserve (NVBR) to evaluate the spatial structure of old forest habitats and to clarify the potential of mature forest stands to serve as a reserve for further development of overmature stands. The following questions were raised: (1) What are the compositional and spatial configuration characteristics of mature and overmature stand pattern? and (2) How does the mature forest pattern relate to the overmature stand pattern as a potential target for sustainable management? In this regard, spatial-statistics analysis was performed for the focal forest stands.

Materials and methods

Study area

The study covered the entire NVBR terrestrial area (Figure 1), located in northern Latvia (central coordinate 57°49’ N; 25°03’ E). NVBR is the largest protected area (terrestrial area 457,708 ha) in Latvia, established in 1997 under the UNESCO programme “Man and the Biosphere”. The forest area of the area is 191,147.7 ha, which comprises 6% of the total forest area in Latvia (Latvijas Statistika 2011).

The conservation aim of the territory is to protect natural values and landscapes of international significance, promoting sustainable economic and social development (Urtans and Seilis 2009). However, the NVBR is no different from any other landscape of Latvia in regard to logging restrictions, as designation as a biosphere reserve is not associated with any additional restrictions above those that exist in specific areas of the biosphere designated in legislation as protected. In other words, forest management outside of protected areas of the biosphere reserve is no different from that outside of the reserve. The NVBR area is comprised of woodland, agricultural lands, built-up areas, lakes, bogs and swamps. Approximately one half of all the forest is state-owned and other half is mostly owned by private owners. A small part is owned by municipalities. Further, the private and municipal forest area is grouped together as “non-state” forest). Almost the entire forest area consists of commercial forest, excluding several nature protection reserves and one Nature Park.

The area of NVBR is large and diverse – it can roughly be divided into three main sub regions (Figure 1): the coastal plain in the western part with extensive forest cover; the Lake Burtnieks plain in the central part, dominated by agricultural areas with forest patches and the Ērģeme hilly area, characterized by mosaic landscape of forest and open territories.

The climate is moderate and precipitation exceeds evapotranspiration. Mean annual temperature is +5.5°C and mean precipitation is 700-800 mm with about 500 mm falling in the growing season. Moraine relief with sandy clay and clay sand sediments is dominant in this area (Tērauds et al. 2011). In general, mixed forest is typical in Latvia, which is located between boreal and nemoral forest biomes, resulting in merging vegetation elements from both (Tērauds et al. 2011).

The study area is dominated by mixed forest with birch, pine and spruce. The Coastal plain is covered mostly by mixed birch-pine or birch-spruce forest with pine forest on sandy or peat soils. In the Burtnieks plain, agriculture has left only remnant forest patches on hills, which are mostly covered with pine-dominated stands or deciduous stands in river valleys. The forest of Ērģeme hilly area mainly consists of spruce-pine and pine stands with admixture of birch.

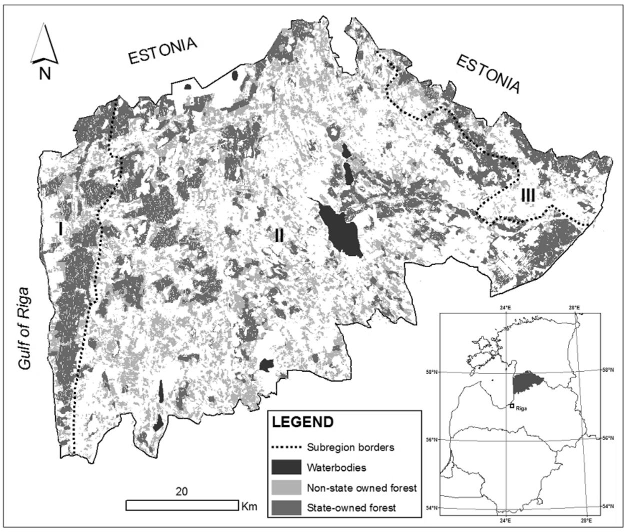

Figure 1. Study area of NVBR. I – Coastal plain, II – Burtnieks plain, III – Ērģeme hilly area

Data acquisition

Forest inventory data for the year 2011 was obtained from the State Forest Service. Forest inventory database is a compilation of field survey results, done by certified forest valuators. There was no ground-truthing done by authors to verify the accuracy of inventory data. This data, available as a GIS database was processed in GIS environment, in which stand boundaries are delineated. Of the total area of 191,147.7 ha, state-owned forest area comprised one half. Non-state forest here includes municipal and private forest.

The forest stands were grouped by the dominant tree species as Scots pine (*Pinus sylvestris* L.), Norway spruce (*Picea abies* (L.) Karst.), silver and downy birch (*Betula pendula* Roth. and *Betula pubescens* Ehrh.), black alder (*Alnus glutinosa* (L.) Gaertn.), Eurasian aspen (*Populus tremula* L.), pedunculate oak (*Quercus robur* L.) and European ash (*Fraxinus excelsior* L.) (Table 1). Stands dominated by, for example, grey alder (*Alnus incana* (L.) Moench.) were not considered to very low area in the NVBR.

Stands were generally grouped into two categories – mature (over cutting age) and overmature (biologically old), stand ages were derived from forest inventory database information. However, when cutting age thresholds (VMD 2000) differed between forest site types, the mean threshold age was used (Table 1).

Table 1. Stand age thresholds used in data selection (modified from VMD 2000)

Species	Age threshold (years)	
	Mature	Overmature
Eurasian aspen	41	61
Silver and downy birch	61	81
Black alder	71	91
European ash	81	121
Norway spruce	81	121
Pedunculate oak	111	151
Scots pine	121	141

Data analysis

The first phase of data processing was performed in ArcGIS environment. Selected data layers were compiled and converted into raster data format (ArcGRID). Raster images had a selected cell (pixel) size of 10×10 m, giving high landscape resolution. FRAGSTATS analysis was applied using only relevant metrics with minimal interdependency describe the stand patterns comprising forest structure. Since the input data has identical extent and spatial resolution, calculated metrics are mutually comparable. As the basic indicators for characterizing the landscape pattern, seven metrics were chosen, based on the literature (McGarigal 2002, Wu et al. 2000). Class area (CA, measured in hectares) was the sum of areas of all patches of the same type. Identical to it, TA (total area) was used at the landscape level. The number of patches (NP) showed how many patches comprise the pattern of the particular class. Mean patch area (AREA_MN) indicates the mean patch area. Proximity index (PROX_MN), which was developed by Gustafson and Parker (1992), characterized the mean patch isolation by considering the size and proximity of all patches with edges within a predefined threshold distance. Since this study was aimed at a general assessment of stand pattern, threshold distance was chosen arbitrarily as 300 m, corresponding to 30 pixels in the landscape model. Mean shape index (SHAPE_MN) was the ratio between perimeters of measured patches and minimal possible perimeter of patches of the same area (e.g. square-shaped). Mean Euclidean nearest neighbour distance (ENN_MN) metric evaluated the patch isolation in sense of minimum distance between patches of the same type. Aggregation index (AI), developed by He et al. (2000), measures cell adjacencies in class or landscape levels to characterize patch spatial distribution. For metrics averaging lower level metric values standard deviations (AREA_SD, SHAPE_SD, PROX_SD and ENN_SD) were shown (Table 2).

FRAGSTATS analysis (McGarigal et al. 2002) was conducted separately for mature, overmature and all forest stands. After defining the required metrics, parameters and variables, seven metrics were calculated in each analysis. For calculating isolation metrics, the „8 cell neighbour" method was used. Significance levels were calculated for differences in metric values (AREA_MN, SHAPE_MN, PROX_MN, ENN_MN) between state and non-state forest areas using the non-parametric Wilcoxon test (α=95%) conducted with R software (R Development Core team 2008). The *p* values were adjusted using the method Holm.

Results

Considering all forest as one class, the forest area (41.8% of its terrestrial area) in the landscape had fairly large patch areas (26.79 ha) with a mean distance of 2,110.76 m from each other and patch aggregation (AI=96.7%). Although total area of state and non-state forest was almost equal (49.2 and 50.8% in state and non-state stands respectively), their spatial patterns differed greatly (Table 2). Mean area of forest patches was much higher for state forest, while non-state forest patches were more numerous (NP=1,127 and 6,007, respectively) and less isolated.

Also patch number in non-state mature stands was almost twice as high as in state-owned stands, but the patches were smaller (AREA_MN=1.49 and 2.69 ha, respectively). Also, mature stands had slightly higher aggregation (AI=91.07). The spatial patterns for overmature forest patches showed less pronounced differences than those for mature stands. Total stand area of state-owned overmature forest was higher (TA=7,015.3 *versus* 4,346.0 ha in non-state forest), but patch number was similar (Table 2). Overmature patch size was small (mean 1.34-2.14 ha) for both ownership types. Patch shapes were more compact for overmature non-state forest patches. State-owned forest patches had higher proximity and isolation measures, as well as aggregation index (AI=90.17 and 88.06). This difference in aggregation was similar to that for mature forest patches.

Significant differences between two ownership types in patch size, shape, proximity and isolation were tested for patches divided by tree species (Tables 3-4). Regarding mature forest, the patterns for birch patches differed for all tested indices and pine for all except shape. Other species showed significant differences in some of these indices. Birch and aspen dominated stand area of overmature stands significantly differed between state and non-state forest in all tested metrics. This was also true for black alder, excepting for patch shape. From remaining species only pine and spruce in one aspect of pattern properties (patch area and isolation, respectively). Of the metrics indices tested, patch shape (SHAPE_MN) showed the least significant differences in patches segregated by ownership type.

Compared to the area of overmature forest, the area of mature forest was higher for pine, spruce, black alder and particularly birch, in both ownership types

Table 2. Landscape level metric values and standard deviations for total forest area, mature and overmature stand patterns, divided by state and non-state forest area

	Total forest area			Mature		Overmature	
	Total	State	Non-state	State	Non-state	State	Non-state
TA, ha	191147.7	94099.3	97048.4	14624.4	13630.7	7015.3	4346.0
NP	7134	1127	6007	5437	9154	3281	3254
AREA_MN, ha	26.79	83.50	16.16	2.69	1.49	2.14	1.34
SHAPE_MN	1.89	2.04	1.86	1.59	1.54	1.55	1.49
PROX_MN	2110.76	7250.37	1146.49	18.31	7.05	7.35	3.11
ENN_MN, m	88	119	82	390	413	561	698
AI	96.68	97.70	95.69	91.02	88.18	90.17	88.06
	Standard deviations from category means						
AREA_SD, ha		376.58	66.20	4.68	2.30	2.88	2.00
SHAPE_SD		1.58	0.92	0.44	0.39	0.39	0.34
PROX_SD		18313.98	3713.93	82.01	24.71	27.13	11.20
ENN_SD, m		295.93	119.37	1010.74	798.13	1268.43	1500.46

(Tables 3-4). However, the area of overmature aspen-dominated stands was greater than mature stand area.

Of the mature stand area, the area dominated by the tree species much differed between state and non-state forest area – birch dominated in both (approximately 70 per cent), but in non-state forest mature pine stands had a total area that was four times less, while the spruce-dominate area two-times higher, compared to state forest (Table 3). State-owned mature forest also had larger areas of black alder and ash. As expected, mature birch patches had the highest density, particularly in non-state forest. Mean patch area was generally larger for state forest, especially for mature birch and pine stands. Aspen stands had the most compact patch shape for both ownership types (SHAPE_MN=1.46-1.42). More complicated shapes were observed in mature pine, birch and oak stands, with higher shape indices in state-owned forest. Mean patch proximity was generally higher in state forest for all species, especially birch (PROX_MN=27.36). However, Euclidean neighbor distances were higher in state forest only for spruce and oak pattern, suggesting indicated lower patch isolation in non-state mature stands. Patch aggregation was higher in state-owned mature stands, reaching 91.61% for birch.

Table 3. Class level metric values for mature stand patterns

	O.	pine	spruce	birch	b. alder	aspen	oak	ash
CA, ha	S	1964.6	1205.3	10258.7	685.9	361.4	65.2	83.4
	N-S	465.3	2528.3	9708.8	409.2	371.2	89.4	58.6
NP	S	775	812	3131	390	242	33	54
	N-S	323	1841	5888	365	575	97	65
AREA_MN, ha	S	**2.53**	1.48	**3.28**	**1.76**	**1.49**	1.97	1.54
	N-S	**1.44**	1.37	**1.65**	**1.12**	**0.65**	0.92	0.90
SHAPE_MN	S	1.62	1.51	**1.62**	1.55	1.46	1.59	1.45
	N-S	1.54	1.50	**1.56**	1.50	1.42	1.52	1.44
PROX_MN	S	**10.17**	5.10	**27.36**	3.08	**1.61**	6.49	**1.11**
	N-S	**2.87**	2.86	**9.62**	2.56	**0.75**	2.47	**0.56**
ENN_MN, m	S	**429**	536	**184**	**693**	1156	3112	**2320**
	N-S	**1109**	442	**193**	**1134**	1004	2485	**3731**
AI	S	90.45	88.622	91.61	89.05	89.33	90.75	89.68
	N-S	88.38	87.86	88.51	86.91	83.50	85.64	86.62

O. – ownership type: S – state-owned, N-S – non-state-owned stands. Significant (p<0.05) differences between state and non-state owned stand metric values are bolded

Within the category of overmature stands, there was very uneven species distribution in non-state forest: birch and aspen together comprised 90% of total area (Table 4). In state-owned forest overmature pine, birch and aspen together comprised 87% of total forest. Patches in state-owned overmature forest were generally larger, only spruce showed similar mean patch size (AREA_MN=2.63 ha) to that in non-state stands. Patch shapes were quite similar in stands under both ownership types, with minimal differences between species. Both proximity and patch isolation metrics had generally higher values for state-owned overmature forest. Overmature oak and pine stands appeared to be much less isolated in state forest. Aggregation was also higher for state forest patterns of all species, except spruce.

Table 4. Class level metric values for overmature stand patterns

	O.	pine	spruce	birch	b. alder	aspen	oak	ash
CA, ha	S	1448.1	257.7	3181.2	430.0	1573.3	39.5	85.5
	N-S	195.3	142.0	3115.7	83.4	781.0	21.6	7.0
NP	S	543	161	1449	238	839	19	32
	N-S	129	54	2127	82	834	21	7
AREA_MN, ha	S	**2.67**	1.60	**2.20**	**1.81**	**1.88**	2.08	2.67
	N-S	**1.51**	2.63	**1.46**	**1.02**	**0.94**	1.03	0.99
SHAPE_MN	S	1.59	1.50	**1.58**	1.52	**1.49**	1.44	1.57
	N-S	1.57	1.48	**1.50**	1.45	**1.43**	1.53	1.60
PROX_MN	S	12.13	1.80	**8.42**	**2.74**	**5.13**	0.99	1.49
	N-S	7.54	0.64	**3.61**	**0.67**	**1.66**	0.04	0.06
ENN_MN, m	S	570	**1514**	**337**	**1007**	**463**	2793	3642
	N-S	1597	**3469**	**396**	**2724**	**740**	7184	6438
AI	S	90.89	89.39	90.11	89.38	89.82	92.53	91.78
	N-S	88.46	93.03	88.24	87.33	86.43	87.33	87.14

O. – ownership type: S – state-owned, N-S – non-state-owned stands. Significant (p<0.05) differences between state and non-state owned stand metric values are bolded

Discussion and conclusions

As the NVBR, by definition of a reserve, is supposed to represent a model for sustainable development, the area has received attention from and the viewpoints of landscape planning, conservation of biodiversity and sustainable tourism in the study of complex interactions of man and nature (Urtans and Seilis 2009). Considering the extent of commercial forest in the area, maintaining a component of old forest that would be sufficient for conservation of biological diversity is important. The biological conservation often appears to be a problematic aspect for implementing sustainable forest management system (Lindenmayer et al. 2000).

In this study, the term "overmature" was used as a designation of "old" forest, as previously done by others (Kneeshaw and Gauthier 2003, Kurttila et al. 2002, Mladenoff et al. 1993, Wallenius et al. 2002). Managed forest younger than 70 years old rarely contain structures typical of natural forest (Angelstam et al. 2005) and thus lack many species. However, an age of 70 years is the average cutting age in commercial forest. Siitonen et al. (2002) argued that consideration of spatial objectives is mandatory to assess old forest stand networks as a complement to existing reserves in Northern Finland.

In the NVBR, the overall structure state-owned forest patches at the landscape scale had more integrity compared to other stands. State forest was composed of large, continuous tracts with significantly larger patches and higher proximity, while the non-state pattern had more dispersed and generally smaller patches. These are obvious consequences of the centralized management of state forest resources, in contrast to many small forest owners with diverse management strategies. The area of overmature stands in state-owned forest is higher in comparison to non-state forest, but the number of patches is similar, Thus, the non-state forest is more fragmented with smaller patches with less connectivity. This suggests that landscape management for conservation should be focused on state forest, as this would be more cost-efficient considering the conditions of only one land owner and present fragmentation level. However, the spatial patterns of state forest show insufficiency of patch size, which had a mean smaller than 3.28 ha for all tree species (Table 3), and patch size was even lower for non-state forest (except for spruce). Clearly, a patch size of a few hectares is far from that present in a natural landscape, and cannot support the full range of disturbance-driven successions (Kuuluvainen 2002). The low patch size of overmature forest in Latvia is not surprising, as the forest area in Latvia has almost doubled in the last 100 years, i.e. a large proportion of stands are young. Spruce was the focus for planting in the Soviet period (Tērauds et al. 2011), but these stands will reach the mature stage not earlier than in 2030. The lack of overmature pine stands and relatively large areas of overmature aspen are the consequences of active timber extraction with pine as a main target species and aspen as an early-successional species in natural regeneration process in clear-cuts during the pre-war era (Tērauds et al. 2011). Also, the simple shapes of aspen patches also suggest origin as successional stands in clear-cut areas. Despite the deficiencies in connectivity, at the landscape scale, centralized management resulted in a pattern more favourable for facilitating ecological connectivity than in non-state forest.

The landscape patterns of mature forest patches can be used to determine the potential of this age class in replenishing overmature stands in the future, with the aim to improve connectivity. Again, the spatial pattern of state forest is less fragmented, which was evident for most spatial metrics (area, shape, isolation and aggregation) for the trees species examined. However, outside of protected areas these stands can and probably will be harvested. Therefore, there is a need for setting targets for the amount of overmature forest that should be retained in the landscape in commercial state forest.

In state-owned forest, the highest potential to decrease fragmentation of overmature patches for a tree species was for mature spruce stands. Overmature spruce stands in the studied area cover an area of only 258 ha, while the area of mature spruce forest is almost 5 times larger. However, spruce is one of the main target species for forestry. Nevertheless, spruce stands are an important habitat for rare species (Kuusinen and Siitonen 2008, Ohlson et al. 1997). A similar difference in mature and overmature forest was observed in non-state forest.

Aspen stands show an opposite pattern – there are much less aspen stands, which could eventually replace current old forest after 20-30 years. These differences are more pronounced in state-owned forest where the amount of mature stands is five times less than amount of overmature stands. Considering that aspen is an early successional species, the overmature aspen stands might be expected to change in the dominant tree species. As old aspen is a key structural element important for biodiversity, the suggested lack of temporal continuity of overmature aspen is a concern, and the restrictions should be made on harvest of this species. The same should apply to mature and overmature oak and ash stands, which have a very low area. However, the oak and ash stands are aggregated in several nature protected areas in state-owned forest, and thus logging of most of these stands is not forecast. In a recent study (Ikauniece et al. 2012) of regional differences in fragmentation of old (over 100 years) nemoral and aspen forest, an insufficiency was noted in the western part of the NVBR.

There is a greater area of mature pine forest in state forest, compared to overmature forest, providing a potential reserve for decreasing fragmentation. However, since pine is the main target species for timber industry it is doubtful that a significant fraction of the existing mature stands will donate to the formation of old forest in nearest future. It is also likely that most of the overmature pine outside protected areas will be lost, unless plans for further protection are adopted.

Among the dominant tree species, birch stands are the least fragmented, and there is a large area in both state and non-state forest of large mature patches with good connectivity. The growing demand of birch timber will probably result in increased harvesting pressure, but the comparatively large amounts of mature and overmature birch area reduce such concerns.

Black alder stands in Europe are a relatively rare wetland forest type that is stable over time given that environmental conditions do not change (Orczewska 2009, Priedītis 1999). The small area of old black alder stands in non-state forest can potentially be replaced after logging by the considerable amount of mature stands, while in state-owned stand pattern this gap is less dramatic. Furthermore, the pattern of non-state stands has smaller and more isolated patches.

Table 5. The proportion of strictly protected stands and WKH's of total area under different ownerships

Maturity class	Ownership	Strict protection (%)	WKH's (%)
Mature	State	1.99	6.7
	Non-state	0.60	0.5
Overmature	State	4.37	25.5
	Non-state	2.80	1.0

Due to the increased intensification of forest harvest in Latvia (VMD 2010), a large supplement to the existing amounts of overmature stand patterns is doubtful for forestry target species, unless targets for improvement of biological diversity are set. In non-state forest, in the next 20-30 years, due to comparably small area of mature and overmature forest, fragmentation will increase further. The area of old birch and spruce forest will potentially increase, while aspen fragmentation will likely increase. Nemoral tree species stands, which already are highly fragmented, most require logging restriction. Calculated of area, at most 4.37% of analyzed overmature stands are strictly protected (Table 5), and much less in non-state forest. Woodland key habitats (WKH) reached 25.5% in state forest, significantly less in non-state forest. This ratio shows the need not only for the supplement for stand patterns, but also for increase of legally protected areas, recognized as WKH's.

The conclusions from this study are limited since fields survey was not conducted to assess factors significant for biodiversity (e.g. dead wood volumes, indicator species) hence it deals only with spatial pattern as one of the components of forest landscape structure. However, old stands can be expected to have a greater potential to support important structures, compared to young stands. The obtained stand patterns, which were standardized in extent and spatial resolution, were comparable and applicable for examination with landscape metrics. This methodology provided opportunity to assess spatial properties of forest landscapes over large areas to determine the area of concern regarding fragmentation of forest, which needs to be considered in landscape level planning of sustainable forestry.

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СТРУКТУРА ПЕРЕСТОЙНОГО ДРЕВОСТОЯ В БИОСФЕРНОМ РЕЗЕРВАТЕ СЕВЕРНАЯ ВИДЗЕМЕ

З. Рендениекс и О. Никодемус

Резюме

Основной целью, поставленной латвийской государственной компанией ОАО „Latvijas Valsts meži" является устойчивое развитие лесопользования. Та же цель устойчивого развития, но на ландшафтном уровне, является главной целью биосферного резервата Северная Видземе, который был выбран исследуемой территорией. В качестве критерия для анализа древостоя основных видов деревьев (сосны, берёзы, ели, чёрной ольхи, осины, дуба и ясеня) был выбран возраст. В рамках исследования были использованы данные о состоянии древостоев в 2011 году. Для получения информации о состоянии древостоев, в том числе и для оценки пространственной структуры спелого и перестойного леса, был использован аналитический подход. Перестойные древостои могут иметь высокую потенциальную ценность в сохранении биологического разнообразия, являющегося одним из ключевых аспектов устойчивого развития лесопользования. Спелые древостои, достигшие возраста рубки (т.е. имеющий наибольший годичный прирост древесины), представляет собой резерв для перестойных древостоев, обеспечивая целостность структуры биологического разнообразия. Результаты исследования, с точки зрения пространственной структуры, показали различный потенциал спелого леса, способствующего развитию биологического разнообразия в ближайшие десятилетия. Со временем, перестойные еловые и березовые древостои могут быть пополнены теперешними спелыми древостоями, в свою очередь спелые осиновые древостои имеют наименьшие перспективы устойчивости как в частных, так и в государственных лесах.

Ключевые слова: перестойный древостой, структура ландшафта, ландшафтные индикаторы