INFLUENCE OF SELECTED FEATURES OF FORESTS ON FOREST LANDSCAPE AESTHETIC VALUE – EXAMPLE OF SE POLAND

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Abstract. The study was designed to examine the relationship between features of forests and the quality of forest landscapes, and to determine the strength of effect of the features in the aesthetic value of the landscape. The methodology applied to assess forest landscapes took into account the following features: forest site humidity, age of forest, terrain slope, site index of stands, species composition of the tree layer, under-story cover, colour and composition, mosaic-like, as well as horizontal structure of the tree stands. The study was conducted in temperate forests located in Central-Eastern Europe – more precisely – in south-eastern Poland. In the investigated area the dominating tree species are: *Pinus sylvestris* L., *Abies alba* Mill., *Fagus sylvatica* L. and *Quercus* L. They cover 42.2%, 20.8%, 20.4% and 6.5% of the total forest area, respectively. The findings show that nearly 1% of the area of the examined forests within the relevant territory are characterized with very high landscape value, over 67% with high, 31% with medium, and less than 0.5% with low landscape value. A strong relationship occurs between terrain slope vs. aesthetic quality of landscape as well as forest site humidity vs. aesthetic quality of landscape. Weak effect was observed for site index of stands vs. aesthetic quality of landscape, and moderate relationship was identified in the case of the remaining features. The findings show the strength of relationship between the features of forests and the aesthetic quality of landscapes, consequently providing a tool for forest managers to develop attractive forest landscapes in selected areas.

Keywords: landscape values, landscape management, aesthetic quality of landscape, temperate forests, tourism, recreation, suburban forests.

Introduction

Looking through the Web of Science database one can find the earliest considerations related to landscape, dating from 1893 (Dennis, 1893). The author rightly points out the large scale aspect of the phenomenon: "A landscape covers several or many square miles"; and further its dynamic quality, such as in the image of: "…a flock of blackbirds suddenly flirting up from among the cattle in the pasture, circling about in a whimsical way, and then as suddenly dropping down again in the same place". Dennis also recognizes limitations of human eye in perceiving landscape. On the other hand the first information pertaining to forest landscapes appears in the database nearly 70 years later, yet it is not related to research focusing specifically on forest landscape which is only a backdrop for research into birds (Drozdova, Taskaeva, & Dobrokhotov, 1960). The first publication reporting a study of landscape dominated by forests dates from 1972 and discusses changes in landscape resulting from human activity over the ages in Great Britain (Nicholls, 1972).

It is a well-known fact that forests positively impact the landscape quality of a given region and, apart from the lay of the land and surface waters, constitute the main component of landscape attractiveness (Dudek, 2012; Petrova et al., 2015; Senetra, 2015; Zhang, Deng, Ma, & Sasaki, 2015). Moreover, compared with other ecosystems, forests generally feature higher rate of biological diversity (Gibson et al., 2011). Therefore, a risk of significant loss in biodiversity results from forest dieback (Martin, Newton, Cantarello, & Evans, 2015), disturbances in forests (Fischer, Marshall, & Camp, 2013) or inadequate forest management (Spiecker, 2003). It has been proved that in the spectator eyes more biodiverse landscapes are perceived as more attractive (Dudek, 2016b), is closely related to them (Bridgewater, 1988; Waldhardt, 2003; Thies & Tscharntke, 1999) and with the ways a given area is used (Sala et al., 2000; Falcucci, Maiorano, & Boitani, 2007; Haines-Young, 2009).

Temperate forests should be dominated by deciduous trees. Yet, until the late 1980s inconsiderate forest management focusing exclusively on profits from sales of lumber,

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led to impoverishment of the tree-species composition in a significant part of European forests resulting in the dominance of coniferous tree-species. In the early 1990s, after the Rio de Janeiro Earth Summit, most European countries, including Poland, adopted a new approach, called sustainable forest management (SFM). One of six SFM criteria reads as follows: "Maintenance, conservation and appropriate enhancement of biological diversity in forest ecosystems"(…). The new model was linked with the necessity to alter the species composition of large-area monocultures mainly consisting of *Pinus sylvestris* L. and *Picea abies* L., as mentioned by Halme et al. (2013); on the other hand the positive influence of the adopted forest policy on landscapes in Poland was discussed by Mederski, Jakubowski and Karaszewski (2009). Despite these well-intended efforts in Europe coniferous forests extend far beyond the border of their natural habitat (Spiecker, 2003; Lorz et al., 2010). According to the Convention on Biological Diversity (CBD), landscape architects and designers also started to pay more attention to conservation and enhancement of biological diversity (Knaapen, Scheffer, & Harms, 1992; Federowick, 1993; Sauer, 1993; Yahner, Korostoff, Johnson, Battaglia, & Jones, 1995). The objective of CBD is to develop national strategies for the conservation and sustainable use of biological diversity, and enabling economic development and benefits for people. It combines traditional efforts aimed at environment conservation with economic objectives related to sustainable use of biological resources. The Convention recognizes the need for significant investments aimed at preservation of biological diversity, and it says that conservation will result in significant benefits for the environment, economy and the society.

The European Landscape Convention (a multilateral international agreement in force from 1 March 2004, approved by 35 states, including Poland) stipulates an obligation to identify and assess local landscapes. The objectives of the Convention include promotion of activities and organization of European cooperation related to landscape issues, mainly focusing on protection, planning and management. Indeed, more and more attention is given to these three issues. Alternative management methods are being discussed in relation to landscape (Gustafson & Crow, 1996; Gustafson, Jay Roberts, & Leefers, 2006; De Groot, Alkemade, Braat, Hein, & Willemen, 2010). Similarly in forest management today there is more and more focus on forest landscape planning. As an example, in Finland it was proposed landscape ecological plans should be developed for all national forests (approx. 1/3 of all forests in Finland) (Kangas, Store, Leskinen, & Mehtätalo, 2000). Concerns related to the loss of biological diversity in forest ecosystems, as well as potential economic benefits contribute to the increased attention to forest landscape management (Baskent & Jordan, 1996). Furthermore, the need to precede forest management planning with assessment of forest landscapes was pointed out by Zanhg et al. (2015).

The author has made an attempt to answer the question which represents the purpose of the present study: is there a relationship between features and landscape values of tree stands and which of these features have the greatest impact on landscape aesthetics? The answer to this question provides grounds for detailed assessment of forest landscape and for implementing the objectives of the European Landscape Convention within the areas of Europe covered with forests.

1. Material and methods

The study was conducted in temperate forests located in Central-Eastern Europe, in south-eastern Poland (21° 25′–22° 30′ E, 49° 40′–50° 10′ N). In the temperate zone of Europe forests occupy approx. 26% of the area (Parviainen, 2005). In Poland forests cover 30.6% of the territory, out of which 81.2% are public, generally accessible forests (Zajączkowski et al., 2014). This means that woodiness in Poland is lower than the average for Europe (32.2% excl. Russia). In the predominant part of Poland the forests are made of *Pinus sylvestris* L. (59.1% of the forest area). On the whole conifers constitute 69.6%. The most common deciduous trees are: *Betula pendula* Roth. and *Betula pubescens* Ehrh. (jointly 7.3%), *Quercus robur* L. and *Quercus petraea* Liebl. (jointly 7.0%), *Fagus sylvatica* L. (5.5%) as well as *Alnus glutinosa* Gaertn. and *Alnus incana* (L.) Moench. (jointly 5.3%). In terms of their age structure, most tree stands are 40–80 years old (45%), while the oldest tree stands, over 100 years of age, occupy 10% of the country's forest area (Zajączkowski et al., 2014).

The study was carried out in state-owned commercial forests administered by five forest districts (Strzyżów, Kołaczyce, Głogów, Leżajsk, Kańczuga). The total of 615 forest units were examined; they comprise an overall area of 16,360 ha which accounts for 25% of the forest areas managed by these five forest districts. In the area of the aforementioned forest districts the dominating tree species are: *Pinus sylvestris* L. (42.2%), *Abies alba* Mill. (20.8%), *Fagus sylvatica* L. (20.4%) and *Quercus* L. (*Quercus petraea* Liebl. and *Quercus robur* L.) (6.5%). The remaining 10.1% of the area is covered by: *Alnus glutinosa* Gaertn., *Betula pendula* Roth., *Carpinus betulus* L., *Larix decidua* Mill., *Acer pseudoplatanus* L., and *Fraxinus excelsior* L. and to a lesser degree by other species.

Majority of the examined tree stands (42.38%) represented the 5th or older age class (classes defined every 20 years). Tree stands of the 4th age class covered 36.26% of the area, 3rd class – 15.00%, 2nd class – 5.25% and the youngest occupied only 1.11% of the area. The low proportion of tree stands representing two youngest age classes (<40 year) results from the long duration of forest renewal and acquisition of lumber from small-area timber felling sites.

In terms of the habitat humidity the ones described as fresh were most abundant (83% of the total area), followed by humid (16%), and wet and marshy (1%). No dry

habitats were identified in the examined area. Exactly 33% of the examined tree stands grow in flat terrain, and the remaining stands cover terrains with varied orography; out of these 31% of the forest area is found on slopes with the inclination of 12°, 35% slope in the range of 13–30°, 1% slope with an inclination >30°. In terms of their horizontal structure, one-story tree stands were found to constitute a majority (65.07%). Two-story and multi-story tree stands were found to occupy 18.51% and 16.42% of the area, respectively.

The selected forest units were assessed for their landscape values from the viewpoint of recreational use, taking into account the following features: forest site humidity, age of tree stand, terrain slope, site index of stands, species composition of the tree layer, understory cover, colour and composition, mosaic-like features determined mainly by the tree cover rate and the type of species mixture, as well as horizontal structure of the tree stands. The data used for assessment were acquired from Forest Management Plans elaborated and being in force for each relevant forest district. Assessment of the forest landscape from the internal viewpoint was conducted with the use of modified Rožkov's method (Ważyński, 1997), described and implemented by Dudek (2016b). When establishing landscape

aesthetic classes, the proportions suggested by Rožkov were kept. He distinguished 5 forest landscape aesthetic classes, with class I comprising tree stands of the highest landscape value, while class V – of the lowest. Key to forest landscape valuation is presented in Table 1.

Subsequently, chi-squared test was conducted to investigate whether there was a relationship between the examined features (all of them were in nominal scale, except for the age class – in ordinal scale) and the aesthetic quality of the landscape (Table 3). In order to apply the test the combined forest units identified for high and very high landscape aesthetic value (1st and 2nd Class – ALC) were compared with the remaining tree stands (3rd and 4th Class – BLC; the 5th Class was not identified in the relevant area). If there was a relationship, its strength was examined with Cramer's V.

2. Results

The findings show that nearly 1% of the forest area within the relevant territory are characterized with very high landscape value, over 67% with high, 31% with medium, and less than 0.5% with low landscape value (Table 2). Yet, it should be remembered that landscape is dynamic.

Table 1. Key to forest landscape valuation (source: Dudek, 2016b)

Number of points	Evaluated feature of forests		Number of points
	Site index of stands	Colour and composition	
1	V	dry pine forest, single-species fir forest, single-species spruce forest	1
2	IV	fresh pine forest, marshy, spruce forest	2
3	III	mixed coniferous forest, riparian, mixed forest	3
4	II	oak, beech, hornbeam forests	4
5	I–I,5		
	Undergrowth cover	Species composition of dendroflora	
1	lack or abundant weeds	single-species tree stands	1
2	abundant weeds	mixed tree stands (2 species), less than 5 tree flora species	2
3	turfy	single-species and mixed tree stands (2 species), 6–10 tree flora species	3
4	mossy-baneberry	mixed tree stands (3–5 species), less than 10 tree flora species	4
5	herbaceous	multi-species tree stands – over 10 species	5
	Tree stand age	Horizontal structure of tree stands	
1	I age class	single-layer tree stands, age class I–II no saplings and understory	1
2	II age class	one-story, age class I–II with weak saplings and understory	2
3	III age class	one-story with strong saplings and understory or ≥III age class	3
4	IV age class	two-story	4
5	≥V age class	Multistory	5
	Habitat humidity	Terrain slope	
1	marshy habitats	very steep and precipitous slopes, slope >30°	1
2	wet habitats	flat terrain	2
3	humid habitats	steep and precipitous slopes, slope 13–30°	3
4	dry habitats	gentle slope, slope up to 7°	4
5	fresh habitats	inclined slope, slope 8–12°	5
	Mosaic-like landscape features		
1	tree stands of I–II age class, very dense with thick tree cover or very thin with thin tree cover 0.1–0.2		
2	I–II age class, tree cover of 0.6–0.7		
3	III and older, tree cover ≥0.7		
4	tree cover of 0.3–0.6 with regular tree distribution, with thick saplings and understory is awarded 3 points		
5	with tree cover of 0.3–0.5 with stands of trees, with thick saplings and understory, is awarded 4 points or fully vital with tree cover of 0.1–0.2		

Landscape will change, forests will "move" over time across classes of the landscape aesthetics, regardless whether these are commercial forests or areas no longer utilized. Such changes also depend on various disastrous phenomena, as a rule impossible to predict, e.g. hurricanes, fires, insect outbreaks. Indeed, during the initial period following their occurrence such phenomena always result in destruction of the landscape.

The present findings provide evidence for the existing relationship between the forest features and the aesthetic value of forest landscapes. A strong relationship (Cramer's V > 0.5) occurs between terrain slope vs. aesthetic quality of landscape as well as forest site humidity vs. aesthetic quality of landscape. Weak effect (Cramer's V < 0.3) was

observed for site index of stands vs. aesthetic quality of landscape, and moderate relationship was found in the case of the remaining features (Table 3).

Tree stands of high aesthetic landscape value (ALC) occur mainly on slopes with an inclination of 13–30° (here constituting 83%) and an inclination of 8–12° (92%). On the other hand tree stands with lower landscape value (BLC) were mainly identified in flat areas (here accounting for 71%). BLC was recorded in 100% of the tree stands at the land inclination exceeding 30°, and ALC in 92% of the areas with inclination up to 7° (Figure 1). However, in both cases the size of the sample was small.

Statistical verification of the findings showed significantly varied effects of habitat humidity in the landscape

Table 2. Forest landscape aesthetic classes for the object of research

Landscape aesthetic class; total number of points	Number of separate forest stands	Forest stands' total area [ha]	% share
I very high landscape value; 39–44	6	151.53	0.93
II high landscape value; 31–38	391	11046.28	67.52
III moderate landscape value; 22–30	216	5136.20	31.39
IV low landscape value; 13–21	2	26.43	0.16
V very low landscape value; up to 12	0	0.00	0.00
Total	615	16 360.44	100.00

Table 3. Relationship between landscape aesthetics and the examined forest features

Statistics: tree stands covered (5, exception – color 4) × landscape aesthetic class (2)		
Forest features	Pearson's Chi^2	Cramér's V
Color	66.2007 df = 4, p = 0.00000	0.328
Site index of stands	26.7492 df = 3, p = 0.00001	0.208
Horizontal structure of tree stands	94.3854 df = 4, p = 0.00000	0.392
Mosaic-like landscape features	84.1920 df = 4, p = 0.00000	0.370
Terrain slope	225.5625 df = 4, p = 0.00000	0.606
Understory cover	119.0960 df= 4, p=0.00000	0.440
Tree-species composition of overstory	77.9133 df = 4, p = 0.00000	0.356
Tree stand age	77.8250 df = 4, p = 0.00000	0.356
Forest site humidity	194.8539 df = 4, p = 0.00000	0.563

$\chi^2 = 225.5625$
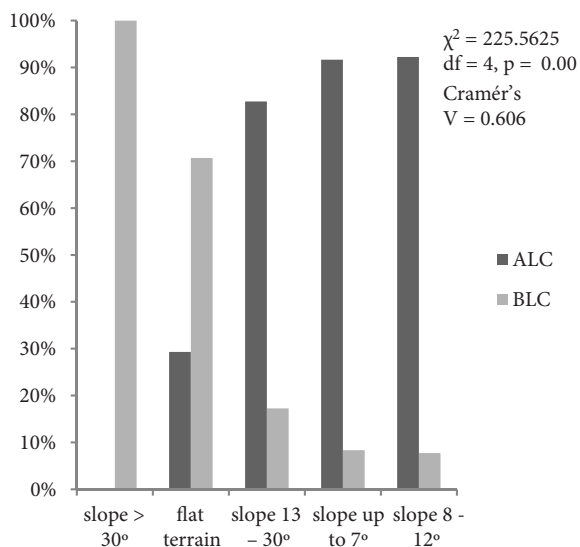df = 4, p = 0.00
Cramér's V = 0.606

Figure 1. Frequency of tree stands representing the specific aesthetic landscape class at specific terrain inclination; ALC – 1st and 2nd landscape aesthetic class; BLC – 3rd and 4th landscape aesthetic class

$\chi^2 = 194.8539$
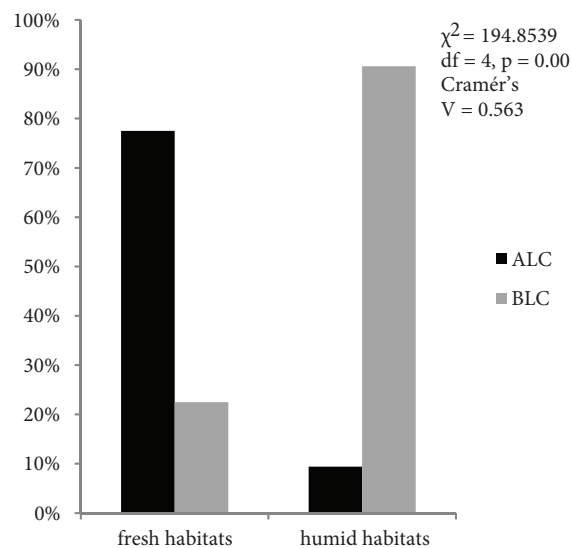df = 4, p = 0.00
Cramér's V = 0.563

Figure 2. Frequency of tree stands representing the specific aesthetic landscape class at the selected forest sites

values of the specific forest stands. Within fresh habitats majority of tree stands (77%) present considerable landscape value (Figure 2). On the other hand in humid habitats tree stands with high landscape value were rather infrequent (ALC approx. 9%).

The other forest stand features examined here were found to moderately correlate with aesthetic landscape classes, yet some relations are visible also in the case of these features (Figures 3–8).
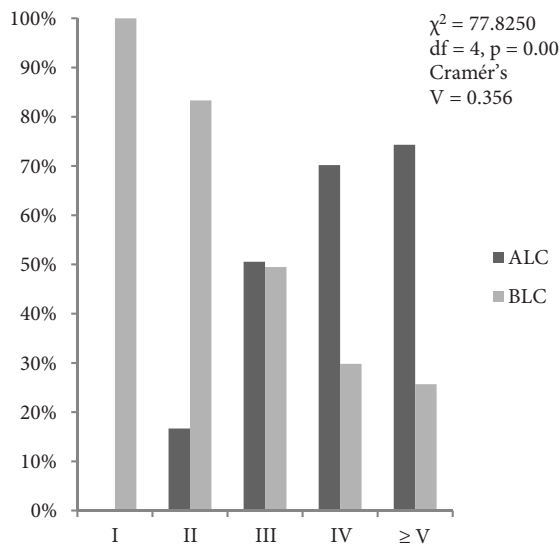
As for the age of tree stands, we can notice that increasing rate of forests with greater landscape values corresponds with growing age. More specifically, in tree stands of up to 20 years of age ALC rate is 0%, at 21–40 years – ALC 17%, at 41–60 years – ALC 50%, at 61–80 years – ALC 70% and at 81 years and more – ALC 74%.

If we take into account species composition of forest stands we can notice that single-species stands (monocultures) are generally found with lower landscape

Figure 3. Frequency of tree stands representing the specific aesthetic landscape class relative to the age of the forest stand: I – tree stands up to 20 years of age; II – 21–40 years; III – 41–60 years; IV – 61–80 years; ≥V over 81 years

$\chi^2 = 77.8250$
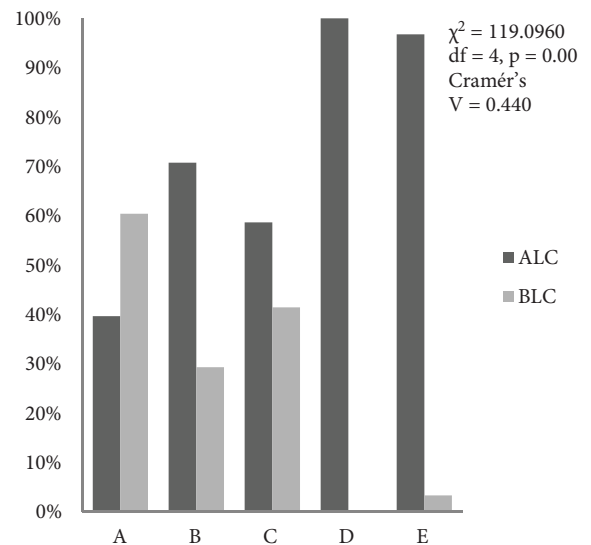df = 4, p = 0.00
Cramér's
V = 0.356

Figure 5. Frequency of tree stands representing the specific aesthetic landscape class relative to the undergrowth cover: A – lack or abundant weeds; B – abundant weeds; C – turfy; D – mossy-baneberry; E – herbaceous

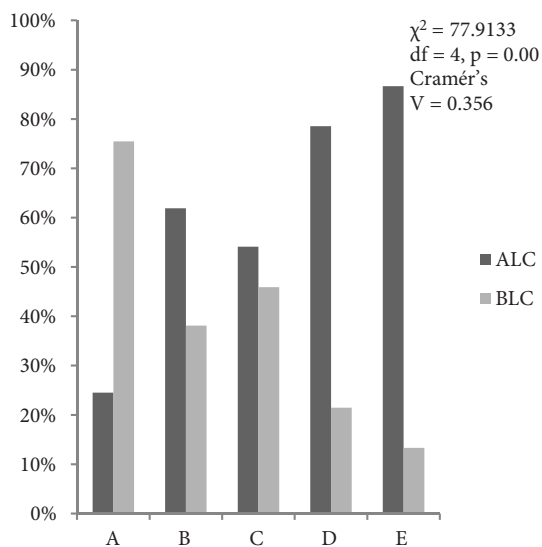$\chi^2 = 119.0960$
df = 4, p = 0.00
Cramér's
V = 0.440

Figure 4. Frequency of tree stands representing the specific aesthetic landscape class relative to species composition of forest stand: A – single-species tree stands; B – mixed tree stands (2 species), less than 5 tree flora species; C – single-species and mixed tree stands (2 species); 6–10 tree flora species; D – mixed tree stands (3–5 species), less than 10 tree flora species; E – multi-species tree stands – over 10 species

$\chi^2 = 77.9133$
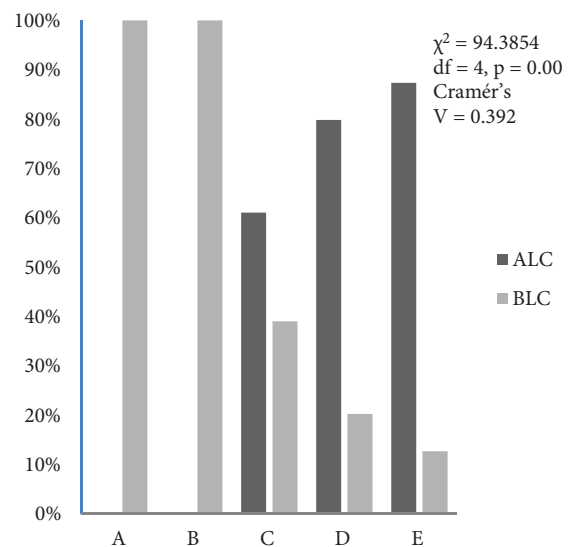df = 4, p = 0.00
Cramér's
V = 0.356

Figure 6. Frequency of tree stands representing the specific aesthetic landscape class relative to the vertical structure of forest: A – single-layer tree stands, age class I–II no saplings and understory; B – one-story, age class I–II with weak saplings and understory; C – one-story with strong saplings and understory or ≥ III age class; D – two-story; E – Multistory

$\chi^2 = 94.3854$
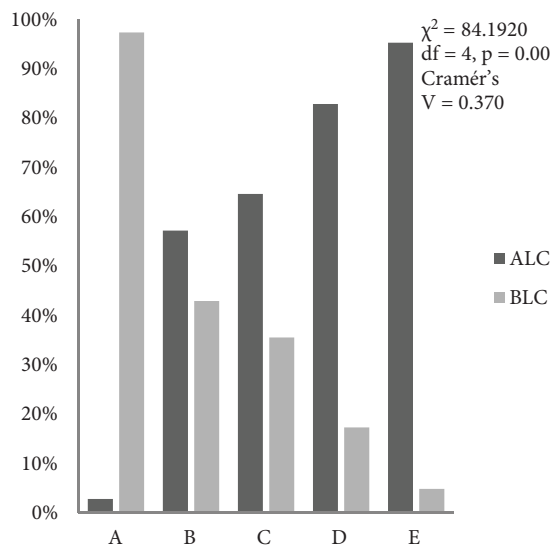df = 4, p = 0.00
Cramér's
V = 0.392

Figure 7. Frequency of tree stands representing the specific aesthetic landscape class relative to mosaic-like landscape features: A – tree stands of I–II age class, tree cover 0.1–0.2; B – I–II age class, tree cover of 0.6–0.7; C – III and older, tree cover ≥0.7; D – tree cover of 0.3–0.6 with regular tree distribution, with thick saplings and understory is awarded 3 points; E – with tree cover of 0.3–0.5 with stands of trees, with thick saplings and understory, is awarded 4 points or fully vital with tree cover of 0.1–0.2
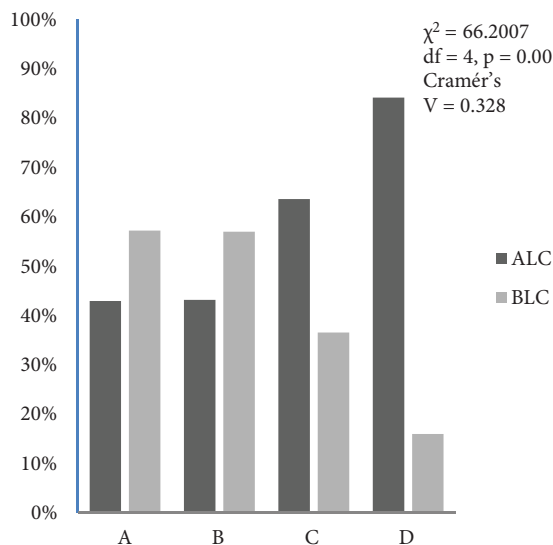
Figure 8. Frequency of tree stands representing the specific aesthetic landscape class relative to the colour – type of forest: A – dry pine forest, single-species fir forest, single-species spruce forest; B – fresh pine forest, marshy, spruce forest; C – mixed coniferous forest, riparian, mixed forest; D – oak, beech, hornbeam forests

value – 75% of such stands are classified as BLC. On the other hand multi-species forest stands (with over 10 tree species) in vast majority (87%) present with high landscape value (Figure 4).

If we examine undergrowth cover, we can see that 97% of the forest stands with herbaceous cover are characterized with high landscape value (ALC). Conversely, the tree stands with poorer landscape value (BLC) as a rule do not feature ground cover, or it is heavily infested with weed (Figure 5).

As for the vertical structure of forest the findings show that more complex structure beneficially affects the forest's landscape value. Majority of two-layer (79% of these classified as ALC) and multilayer tree stands (87% ALC) presented with higher landscape value (Figure 6).

If we examine mosaic-like landscape features, we can notice that almost all the forest stands with lower density of trees and species mixture, and with no dense undergrowth were classified as ALC (Figure 7, E – ALC 95%).

As for the colour of forest, majority of oak, beech and mixed deciduous (mostly hornbeam) forests were classified as ALC – 84%, while BLC is more often identified in monocultures of conifers (Figure 8).

3. Discussion

The acquired evidence shows that inclination of the terrain most significantly affects aesthetic value of forest landscape. The situation is similar in other types of landscape or in landscapes where forest constitutes one of its components (Dudek, 2012) which means it is not

examined from the inside, as a distinctive type of landscape. Conversely, a study assessing forest landscapes in Japan showed that it was surface waters that were the most important element enhancing landscape aesthetics (Zhang et al., 2015). Russian and Japanese research confirms that the most important element of landscapes for the Japanese is water, and for Russians topography (Petrova et al., 2015). The approach adopted in the present study did not take into account the impact of surface waters on the quality of forest landscape; yet the present study did investigate such effect of forest site humidity and showed a strong relationship between the latter factor and the aesthetic value of forest landscapes (Table 3), the most attractive being the forests growing in fresh habitats and the least attractive are those in marshy habitats. Hence, attractive quality of forest landscapes depends mainly on the lay of the land and forest site humidity, and only to a lesser degree on the plant associations dominated by trees and tree stand structure. Due to the weak relationship between site index of stands and landscape aesthetics it can be recommended that this feature should be disregarded in future assessments of forest landscape. On the other hand Tahvanainen, Tyrväinen, Ihalainen, Vuorela and Kolehmainen (2001) emphasize that the picturesque value of forests is affected by a number of factors, including species composition, forest structure and forest management. Research has shown that near-natural forests with no traces of human activity are recognized as more beautiful by individuals living in rural and suburban areas while opposite opinion is expressed by those living in urban areas. Jankovska, Straupe, Brumelis, Donis, and Kupfere (2014) argue that

openness of forest stand affects to improve the landscape aesthetic value. According to Shifley, Thompson, Dijak, Larson, and Millspaugh (2006) forest management and intensity of forest exploitation are the main factors affecting forest landscapes. Radeloff et al. (2006) also highlighted the relation between forest management and landscape. It was shown that cut unit size had the greatest impact. Yet the other two components of management examined in the study, i.e. minimum harvest age and target species for management, were also of importance. On the other hand Janeczko (2012), in her study of public preferences related to shaping of forest landscape along roads, came to the conclusion that forest management only mildly affects shaping of landscapes, and in this case the important factors mainly include engineering operations connected with construction of roads (overpasses, embankments, earthworks).

In the assessed area the age structure of tree stands with high proportion of old forests favourably impacts perception of forest landscapes and is also beneficial from the viewpoint of recreational use of forests (Kikulski, 2006; Dudek, 2017). Similarly, the distribution of the tree stands in terms of forest site humidity is favourable. Majority of the examined tree stands grow in fresh habitats. Other studies show that Polish people indeed prefer older tree stands growing in fresh habitats (Skłodowski & Gołos, 2015), like in other regions of Europe (Great Britain, Nordic Region, Central Europe and Iberia), where (age related) size of trees was shown as the major factor affecting positive perception of forest (Edwards et al., 2012).

The term "forest landscape", frequently used in the literature, can be understood as landscape in which forest is a dominating component (e.g. Nicholls, 1972; Turner, Cohen, & Kennedy, 2000; Cottam, Robinson, Heske, Brawn, & Rowe, 2009). Forest landscape is also characterized briefly by a specific type of forest, e.g. pine forest landscape, riparian forest landscape, etc. (Edman, Angelstam, Mikusiński, Roberge, & Sikora, 2011). On the other hand the present study has adopted the approach in which forest landscape is understood as a space limited on all sides by the wall of forest. By crossing the wall of forest we enter the interior of forest landscape. One of the main reasons why in many places worldwide people visit forests is the opportunity to enjoy attractive scenery (Hansson, Külvik, Bell, & Maikov, 2012; Paletto, Ferretti, Cantiani, & De Meo, 2012; Zhang et al., 2015; Tyrväinen, Silvennoinen, & Hallikaine, 2016). Due to these forest areas selected as a result of forest landscape assessment should be managed in ways making it possible to maintain or upgrade landscape value of the tree stands. In suburban forests in Finland the public supports management operations which contribute to development of the most beautiful forest landscapes (Horne, Boxall, & Adamowicz, 2005). Grilli, Paletto, and De Meo (2014) and De Meo, Paletto, and Cantiani (2015) point out that greater emphasis on enhancing forest landscapes, particularly in areas attracting large numbers of visitors, is in the interest not only of the local community but also of the entire region's economy. Gios and Clauser (2009) argue that the greatest benefits from attractive landscapes are gained by: hoteliers, shopkeepers, service firms. Such entities should participate in the costs of creating attractive landscapes, yet this requires adequate policies and regulations. Scientists also recognize the need for the involvement of the societies in planning forest landscapes (Saito, Imura, Okamoto, & Fujiwara, 2007; De Meo, Ferretti, Frattegiani, Lora, & Paletto, 2013). Likewise, Dudek (2016a) claims that forests may play a number of functions and retain landscape stability if the forests designated primarily for recreation are selected by specialists, who also take into account preferences of a given region's residents.

The method involves rating of numerous features of forest stands (see Table 1). The features as examined and described in each forest stand by a team in charge of forest development, once in 10 years; the findings acquired by such teams are accessible to anyone in forest district offices. Therefore, in comparison to traditional landscape assessment procedures (cf.: Johnson, Brunson, & Kimura, 1994), the applied method enables cost and time effective assessment of relatively large areas of forest landscapes (16.000 ha in the present study). The present findings show the strength of relationship between features of forests and forest landscape aesthetic value, consequently providing a tool for forest managers to develop attractive forest landscapes in selected forest areas.

Moreover, the findings show that the features most significantly impacting forest landscape aesthetics (mainly associated with abiotic environment of forest ecosystem), can only be changed to a very small degree. Indeed, we cannot give shape to the terrain, change forest site humidity, and in part understory cover (by reducing density of stands we can increase the number of plants in undergrowth, affect their condition or support occurrence of species requiring more light, yet we cannot influence the potential species composition which results from habitat quality). Nevertheless, in an area with uniform terrain and forest site humidity we can transform forest landscape by means of silvicultural measures which may alter most of the assessed features of tree stands (tree-species composition in over- and /or understory, vertical and horizontal tree-stand structure, and age structure, colour).

Conclusions

The approach applied in the study enables identification of forests with high landscape value, as a result of which it is possible to implement the main assumptions of the European Landscape Convention, i.e. planning, management and protection of the most valuable landscapes within the areas of Europe covered with forests.

To protect and enhance landscape value of the selected forest units the following operations should be implemented:

- drawing up landscape maps of forests taking into account landscape aesthetics classes, based on previous forest landscape assessments,

– establishing multi-species tree stands with dominating deciduous trees which are more typical for temperate forests, with group mixture of species,

– introducing extended felling age, with acquisition of timber either in very small areas or based on single-tree selection (individual trees are cut without significantly thinning the forest stand; this harvesting method produces hardly visible changes to the landscape, yet it is linked with higher costs of timber acquisition since the load is scattered in a large area) and taking advantage of the natural processes of forest renewal,

– in the case of species with larger amplitude of sunlight requirements, growing two- or even multistory tree-stands, and in the case of species with higher sunlight demand, under-planting in groups which total area does not exceed 10% of the area of the forest unit in matter.

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