DOI: 10.2478/frp-2018-0022
Available online: www.lesne-prace-badawcze.pl

Leśne Prace Badawcze / *Forest Research Papers*
Wrzesień / September 2018, Vol. 79 (3): 229–236

ORIGINAL RESEARCH ARTICLE

e-ISSN 2082-8926

Changes in the synthetic index of sustainable forest management at the level of regional directorates of the State Forests in 1993–2013

Anna Kożuch*, Jan Banaś, Stanisław Zięba, Leszek Bujoczek

University of Agriculture in Kraków, Faculty of Forestry, Department of Forest Management, Geomatics and Forest Economics, al. 29 Listopada 46, 31–425 Kraków, Poland

*Tel. +48 12 6625132, e-mail: a.janusz@ur.krakow.pl

Abstract. The aim of our work was to assess the direction of change taking place in the forests of the regional directorates of State Forests (rdSF) based on measurable indicators used to assess sustainable development. Based on a synthetic index (*Z*), changes in the years 1993−2013 were evaluated for individual directorates. We identified the regions with the highest and lowest rates of change in terms of sustainable development dynamics. The analysis was performed using spatiotemporal variables and the main criterion for selecting the diagnostic variables was their availability and comparability over the analysed period. The rdSF variation was assessed with the synthetic index (*Z*), using the method of zero unitarisation. In 1993−2013, favourable changes over time were indeed recorded, reflecting the progress in implementing practices supporting sustainable development in forestry. However, large differences exist between the regional managements in this respect. For the analysed period, the most favourable conditions from the perspective of sustainable forest management were maintained in rdSF Kraków, rdSF Białystok and rdSF Toruń, while the least desirable conditions were found in rdSF Zielona Góra, rdSF Piła and rdSF Warsaw. The greatest rates of beneficial change, on the other hand, were found in rdSF Szczecin, rdSF Kraków and rdSF Wrocław. In turn, the lowest rates of change of the synthetic index (*Z*) were observed in the directorates of Katowice, Piła and Łódź. In summary, measurable indicators of sustainable development are a good instrument for measuring the pace of change in sustainable forestry. They are an effective tool for assessing and reporting progress over time and should also be used when planning and implementing development strategies.

Keywords: sustainable forest management, sustainable development index, temporal and spatial analysis

1. Introduction

The priority of forest management in Poland is forest conservation, the protection of resources, including water and forested land, as well as rational wood production (Act of 1991). The concept of the sustainable development of forestry is considered a constitutional principle. According to Art. 5 of the Constitution of the Republic of Poland (RP) of 2 April 1997, the Republic of Poland provides protection for the environment, guided by the principle of sustainable development (Constitution 1997). Ongoing sustainable forest management should serve the following objectives: (1) to continuously increase forest resources and their share in the global carbon cycle, (2) to maintain the health and viability of forest ecosystems, (3) to maintain the development of the production function of forests, (4) to maintain, protect and strengthen biological diversity in forest ecosystems, (5) to enhance the protective functions of the forest, (6) to strengthen the socio-economic functions of the forest (Szujecki 1997). National documents were developed on the basis of international agreements resulting from the Agenda 21 and the 'Forest Principles' adopted in 1992 in Rio de Janeiro, as well as the achievements of numerous ministerial conferences on the protection of forests in Europe. In the 'Ecological Policy of the State' and the 'Forest Policy of the State', the forest managers placed special emphasis on implementing the principles of sustainable development in forestry (MOŚZNiL 1997; MŚ 2008). Along with changing the economic reality, scientific and technical progress, and the evolving needs of society relating to forests and their func-

Received: 20.04.2018, reviewed: 18.05.2018, accepted: 9.08.2018.

tions, efforts have been made in recent years to update the premises of the country's forest policies (Gołos et al. 2014; Kaliszewski, Rykowski 2015; Zając, Rykowski 2015).

In the 1990s, measures were developed that could be used to assess the direction and progress of the changes in forestry. Polish criteria were defined and sustainability indicators were constructed on the basis of six European criteria agreed to under the MCPFE,[1] which were adapted to the realities of Polish forestry and the objectives set for forest management in Poland. Rykowski (2006) proposed 132 quantitative indicators divided into three types, according to the degree of data availability. The indicators were grouped according to six criteria: (1) forest resources and their share in the global carbon balance, (2) health and vitality of forest ecosystems, (3) production functions of the forest, (4) protection and enrichment of forest diversity, (5) habitat-creation functions of the forest, (6) socio-economic functions of forests (Rykowski 2006). Similarly, Borys (1999) presented and described the significance of 33 indicators that could potentially be a tool for assessing changes in sustainable forest management. These include, for example, the share of forested land in the total area (%), the share of forest area with significant defoliation in the total forest area (%), total renewal and afforestation per unit of area (%) (Borys 1999).

Over the last few decades, numerous changes have occurred in the management of forest resources in the country, resulting, among others, from the conscious implementation of the principles of sustainable development in forestry, particularly the need to protect nature and pressure on the greening of forest management, as well as from the implementation of the social functions of forests. Therefore, it seems reasonable to monitor and analyse the changes taking place in forestry over time.

The aim of the analysis was to assess the direction of changes taking place in forests at the level of the regional directorates of State Forests (rdSF) on the basis of measurable indicators used to assess sustainable development. An attempt was made to use the non-standard method to assess the level of sustainable development in forests. On the basis of the synthetic index (Z), the changes taking place in 1993−2013 in individual directorates were evaluated, and then the regions with the fastest pace of the most favourable changes in terms of the analysed phenomena were identified.

2. Methodology

The analysis was performed in spatiotemporal terms. The rdSF variation in 1993−2013 was assessed in terms of the value of synthetic indicators characterising sustainable forest management, using the method of zero unitarisation, included in the non-standard methods of multivariate comparative analysis. The method is based on the construction of a generic aggregate indicator based on normalised values of the variables (indicators, diagnostic features) and meets most of the criteria that should be followed when choosing the appropriate method to normalise quantitative parameters (Kukuła 2000; Binderman et al. 2009).

The main criteria for selecting the indicators was their availability and comparability in the analysed period. They were treated as equally important diagnostic variables. They were statistically evaluated for differentiation and correlations. For each indicator, the coefficient of variation was calculated − it was assumed that a value less than 10% meant no differentiation and the feature was eliminated from further analysis. A too strong correlation (correlation coefficient above 0.7) of two analysed features also excluded the variable, because it was a carrier of similar information (Nowak 1990). Finally, to analyse the level of diversity among the State Forests regional directorates in 1993−2013, the available measurable indicators of sustainable development proposed by Rykowski (2006) were chosen:

Y_1 – change of forested area over five years (1000 ha)

Y_2 – abundance of resources (m^3/ha)

Y_3 – share of forests threatened by infectious diseases in the total forest area (%)

Y_4 – area of forests covered by fires (ha/1000 ha of forest area)

Y_5 – average area of one fire (ha)

Y_6 – average defoliation index – share of trees with strong defoliation (class 2–3 damage) in the total number of damaged trees (%)

Y_7 – area of forests excluded from production for non-forest purposes (ha/1000 ha of forest area)

Y_8 – annual timber harvest (thousands of m^3/1000 ha of forest area)

Y_9 – average price of wood (PLN/m^3)

Y_{10} – area of ecological areas (ha/1000 ha of forest area)

Y_{11} – the area of excluded seed stands (ha/100 ha of forest area)

Y_{12} – area of commercial seed stands (ha/100 ha of forest area)

Y_{13} – number of choice trees (units/1000 ha of forest area)

Y_{14} – area of protective forests (ha/100 ha of forest area)

Y_{15} – average total employment in the State Forests (persons/1000 ha of forest area)

Y_{16} – average employment in the Forestry Service (SL) (persons/1000 ha of forest area)

Y_{17} – number of nature/forest education facilities (units/1000 ha of forest area)

Y_{18} – number of nature/forest education field activities (classes/forest district)

Y_{19} – area of forest promotional complexes (LKP) (ha/100 ha of forest area)

*The values of variables Y_9 and Y_{10} are as of 1994 due to the difficulty in accessing reliable data for 1993. The values of variables Y_{17}, Y_{18} are from 2008−2013 due to the lack of available objective data in the analyses.

[1] Ministerial Conference on the Protection of Forests in Europe

The sources of the data for the analysis of the direction and dynamics of the changes taking place in the forests were: compilations of the Central Statistical Office titled 'Forestry' (GUS 1994, 1999, 2004, 2009, 2014) and 'Reports on the educational activities of the State Forests' (DGLP 2004, 2009, 2014). Information from the publications 'Large-area inventory of forests' condition. The results of the first cycle (2005–2009)' (BULiGL 2010) and 'Large-scale inventory of the state of forests in Poland. Results for the period of 2009-2013' (BULiGL 2014) were also analysed.

The variables, or diagnostic features, were divided into stimulants and inhibitor (de-stimulants) of the studied phenomenon (Borys 1978; Kukuła 2000; Borkowski et al. 2007, 2006; Młodak 2006). In the analysis of the impact of the above-mentioned diagnostic variables on the studied phenomenon, a set of stimulants was distinguished:

$$S:\{Y_1, Y_2, Y_8, Y_9, Y_{10}, Y_{11}, Y_{12}, Y_{13}, Y_{14}, Y_{16,} Y_{17}, Y_{18}, Y_{19}\},$$

whereas the variables considered de-stimulants were:

$$D:\{ Y_3, Y_4, Y_5, Y_6, Y_{7,} Y_{15}\}.$$

In order to normalise the diagnostic variables, the method of zero unitarisation was performed according to the following formulas (Kukuła 2000):

$$\text{for the stimulant } Z_{ik} = \frac{(Y_{ik}) - \min(Y_{ik})}{\max(Y_{ik}) - \min(Y_{ik})}$$

$$\text{for the de-stimulant } Z_{ik} = \frac{\max(Y_{ik}) - (Y_{ik})}{\max(Y_{ik}) - \min(Y_{ik})}$$

where Y_{ik} – the output value of the k^{th} feature value in the i^{th} unit; $maxY_{ik} \neq minY_{ik}$.

After grouping the indicators into stimulants and de-stimulants and their normalization, the synthetic Z index was calculated according to Kukuła's formula (2000):

$$Z = \frac{\sum Z_{ik}}{k}$$

where z_{ik} – normalised value of the k^{th} feature in the i^{th} unit, k – number of diagnostic features.

In the spatiotemporal analysis, synthetic indicators (Z) were calculated for individual regional directorates of State Forests for 1993, 1998, 2003, 2008 and 2013. The indicator values reflect the current state and dynamics of change in sustainable forestry, and assume values from 0 to 1. The closer the indicator value is to 1, the better the situation of the directorate for the given analysed phenomenon (Kukuła 2000).

In addition, the characteristics of synthetic indicators were calculated, such as the arithmetic mean of *Zśr* and the standard deviation $S(Z)$, constituting the basis for dividing the analysed units into four groups (Nowak 1990; Kukuła 2000):

group I $Z \geq Zśr + S(Z)$; group II $Zśr \leq Z < Zśr + S(Z)$;
group III $Zśr - S(Z) \leq Z < Zśr$; group IV $Z < Zśr - S(Z)$

According to this classification, the regional directorates in the first group have the highest level of implementation of sustainable development principles in comparison with other units. The directorates with the lowest values of the Z index were categorised to the fourth group. On this basis, the areas with the most favourable situation in terms of the analysed phenomenon were identified, as well as areas deviating *in minus* from the average values. Regions with the largest and smallest dynamics of favourable change were also distinguished.

3. Research results

The analysed variables showing the greatest variation (high coefficient of variation) in the analysed period included: change of forest area within five years, area of forests covered by fires, area of forest land excluded from production for non-forest purposes, area of ecological zones, area of forests protecting water resources and the LKP area. A clear upward trend in most rdSFs in the analysed time intervals were observed in such diagnostic variables as: average abundance, annual timber harvest, price of wood and area of protective forests. The regional directorates of the State Forests also showed a slight increase in the indicator for employment in the Forestry Service, with a simultaneous decrease of total employment in the State Forests.

In the analysed period, forest area increased, but the value of the indicator decreased over time: in 2003 compared to 1998, this value was 5,300 ha, whereas between 2008–2013, it was 1,200 ha (GUS 1999, 2014). The least favourable situation in terms of forest area change occurred in 1993–1998 in the Olsztyn and Lublin rdSFs, and the most favourable was in the Warsaw and Radom rdSFs (GUS 1994, 1999). In 1993, the highest abundance was characterised by stands in the Krosno rdSF (243 m^3/ha), the lowest – in the Zielona Góra rdSF (149 m^3/ha) (GUS 1994). The average abundance was 193.5 m^3/ha and increased to 273.7 m^3/ha over two decades (BULiGL 2010, 2014). In 2013, the highest abundance was found in the Kraków rdSF stands (337 m^3/ha), and the lowest in the Zielona Góra rdSF (242.5 m^3/ha) (GUS 2014). The highest risk of infectious diseases occurred in the Kraków rdSF (16.9%) and Krosno rdSF (16.2%), the lowest in the Zielona Góra rdSF (1.8%). The highest amount of damage caused by forest fires occurred in the Zielona Góra (1.35 ha/1000 ha of forest area), Wrocław and Warsaw rdSFs (0.1 ha).

The largest area of forest stands affected by defoliation in 1993 was found in the Katowice rdSF, whereas the Białystok rdSF forest stands were found to have the best health condition (GUS 1994). In the following years, the situation slightly deteriorated, as the average ratio in 2003 increased by 0.4 in

relation to 1993 (GUS 2004); and in the next decade, it decreased to 1.7. In 1993, the largest forest area excluded from forest production was in the Łódź rdSF (218.4 ha/1000 ha), the smallest in the Warsaw rdSF (0.1 ha). In 1998, the largest amount of land excluded from commercial forest production was in the SF regional directorates of Łódź and Katowice, and this trend continued for the next five years. The coefficient of variability of the analysed feature decreased in 1993−1998 by 0.7, and in 2008, it amounted to 0.6. The least amount of forest area excluded from production was in the Piła and Kraków rdSFs. The highest rates of obtaining wood raw material from a 1000 ha area at the beginning of the analysed period was recorded for the Piła (3,900 m^3) and Katowice (3,800 m^3) rdSFs, the lowest in the Lublin (2,200 m^3) and Warsaw (2,300 m^3) rdSFs. The dispersion of the values around the average was small. In 2013, the maximum timber from 1000 ha was obtained from the Szczecinek (6,000 m^3), Szczecin (5,600 m^3) and Wrocław (5,500 m^3) rdSFs, and the lowest from the Łódź rdSF (4,400 m^3) (GUS 2014). The variation in the analysed feature was significantly lower than in 1993, the coefficient of variation in 2013 was 10%. At the beginning of the study period, the highest nominal price of wood raw material sales was obtained by the Szczecinek (65.31 PLN/m^3) and Kraków (64.74 PLN/m^3) rdSFs, while the lowest was obtained by the Warsaw rdSF (48.50 PLN/m^3) (GUS 1994). In 2013, the highest amount paid for wood was obtained by the Wrocław (PLN 195.7/m^3) and Kraków (PLN 193.9/m^3) rdSFs, and the lowest by the Warsaw rdSF (PLN 158.9/m^3) (Central Statistical Office, 2014). There was also little variation within this feature throughout the study period (roughly 10%).

The largest amount of ecological zones per 1000 ha of forest area was found in the Wrocław and Krosno rdSFs, and the smallest amount was in the Szczecin, Szczecinek, Warsaw and Białystok rdSFs. The rdSF in Kraków was characterised by the largest area of excluded seed stands per 1000 ha of forest (4.8 ha), while in the Zielona Góra rdSF, this area was only 0.06 ha. The largest number of protective forests was recorded in the Krosno and Kraków rdSFs, and the least in the Olsztyn rdSF.

Average employment in the State Forests in 1993 was 11.1 persons/1000 ha, while in 1998, it decreased to 5.3 persons. In the subsequent years, this indicator was characterised by increasingly lower values, amounting to 3.5 in 2013. In 1993, the highest employment rate in the State Forests was recorded in the Kraków rdSF (2.8 persons/1000 ha), while the lowest was in the Zielona Góra, Szczecin and Szczecinek rdSFs (1.5 persons). The average employment rate in the State Forests was 2.0 in 1993, increasing to 2.3 in 1998, remaining at this level until 2008, and then increasing by 0.1 in 2013 (GUS 1999, 2009).

In 2003−2008, the largest number of facilities for the nature and forest education of society existed in the Kraków rdSF (0.36 units/1000 hectares), while the smallest number was in the rdSFs of Zielona Góra (0.14), Szczecin and Szczecinek (0.17) (DGLP 2004, 2009). In 2013, the value of this indicator increased in most directorates by an average of 0.1. In 1998, the Forest Promotional Complexes (LKP) comprised the largest share of forest area in the Toruń rdSF, and in 2013, in the Radom rdSF. The average rate in 1998 amounted to 6.6 ha/100 ha, and in 2013, this increased to 18.1 ha/100 ha (DGLP 2014).

Based on the mean value of the standard deviation and the synthetic index (Z), individual SF regional directorates were classified. Four groups were distinguished: I − directorates characterised by the highest level of sustainable development as reflected by the analysed indicators, II − directorates characterised by a high level of implementation of sustainable development principles, III − medium-level directorates, and IV − directorates with the lowest level of indicators. The division of the SF directorates into groups depending on the value of the synthetic index (Z) reflects their diversity. The directorates maintaining relatively stable positions in the ranking in 1993−2013 were, among others, the SF regional directorates in Kraków, Krosno, Poznań, Radom and Zielona Góra (Table 1). The value of the synthetic indicators increased from 1993 to 2013 in the Lublin and Szczecin rdSFs. The highest dynamic of positive change in 1993−1998 was recorded for the rdSFs in Zielona Góra and Toruń. In turn, in 2003−2008, the highest rate of favourable change was found for the Radom rdSF (a change in the ranking from 10 to 3). In the analysed period, most of the studied directorates experienced a reduction in the rate and scope of anticipated changes, including the SF regional directorates of Toruń, Gdańsk, Katowice and Łódź. In 1993, the situation in the Katowice rdSF was favourable, and it was classified to the first group (2nd place in the ranking), but in 2013, this directorate dropped to the third group (12th place in the ranking), characterised by a lower than average level of positive change. The other regional directorates occupied the same position at the beginning and the end of the study period. In the analysed period, the Kraków rdSF continuously ranked first. Theoretically, this directorate had the most favourable changes in forest management in accordance with the principles of sustainable development. Equally beneficial processes in sustainable forest management were found, among others, in the SF regional directorates of Białystok, Toruń, Radom and Krosno. The Zielona Góra rdSF was found to have the lowest rank for the analysed indicators in the study period. It is worth adding that in 1993−1998, this directorate exhibited the highest increase in the value of the synthetic index. On the basis of the analysed variables, the SF regional directorates of Piła, Warsaw and Szczecinek performed worse than average.

4. Discussion

On the basis of the selected sustainable development indicators (diagnostic variables), and consequently the synthetic

index (*Z*), the directorates were divided into groups that denoted the direction and dynamics of the changes taking place in the forests managed by the individual State Forests regional directorates. The choice of variables supplying the model is one of the most important and the most difficult of preliminary activities (Walesiak 2004). The variables included in the analysis influence the values of the synthetic variable and the grouping process itself. The reliability of the final classification results and, consequently, the accuracy of the conclusions and decisions made on their basis, mainly depends on the quality of the selected set of diagnostic variables. Due to the incomplete picture resulting from limited access to numerous indicators that could be used to assess the sustainable forest management of regional directorates in 1993−2013, the results of the analysis should be treated with reserve. There are numerous variables and factors that have not been included in the analyses. It is worth trying to develop new methods and tools enabling in-depth analyses to be made, taking into account the rank of the indicators, including those found to be difficult to obtain and/or unavailable.

The analysis conducted provides information on the state of forestry in the regions and reflects the rate of change taking place in the forests of the individual directorates. The lowest values of the synthetic index were obtained for the Zielona Góra rdSF, despite the fact that this region is characterised by the highest share of forested area in the country (49%). This area is dominated by pine monocultures characterised by low resistance in poor pine forest habitats (83.7%). The tree stands are also strongly genetically distorted due to the past commercial activities of Germany that focused on maximising profits (RPO 2004). As a result, this area has one of the smallest shares of genetically valuable stands in the country. In addition, the lower than SF average tree stand age means that it has the least amount of resource abundance. The factors just described contributed the most to qualifying this directorate to group IV. The situations of the rdSFs in Piła and Warsaw were equally unfavourable in terms of the analysed phenomena. The most favourable situation during the research period was in the Kraków and Bialystok rdSFs. The Kraków rdSF is characterised by a large area of protective forests and the highest level of tree stand resource abundance in the country. A feature of the region is the largest area share of silver fir (20.3%) and beech (26.4%) in Poland. The age of tree stands in the Kraków rdSF is about 15 years higher than the SF average age of forests. In addition, the high selling price of the wood in this region has contributed to the maintenance of its high position in the ranking for twenty years. The conducted classification accentuates the diversity among the directorates in the analysed features. It is difficult to unequivocally identify the environmental factors, in the broad sense of this word, having a decisive impact on the level of change and progress in sustainable forest management.

When evaluating entities (e.g., SF directorates) in terms of implementing sustainable forest management, it is worth taking into account the specificity of the regions, as well as the rate of change taking place over time, that is, the desirable values of the indicators. The State Forests regional directorates are differently predisposed in the field of forest functions and sustainable forest management. This is a consequence of numerous natural and economic conditions, and even historical ones, independent of the decisions taken by those currently managing the forests. Each SF unit is characterised by individual capabilities as well as potential that should be taken advantage of to shape and develop forest functions in accordance with the principles of sustainable development. In addition, the sustainable development of the country's regions depends on, among others, commercial forest management, which is why sustainable forestry should not be discussed in isolation from socio-economic needs.

In the 1990s, many authors (Szujecki 1995; Barzdajn et al. 1997; Szymański 1997) believed that Polish forest management is still focused on wood production. According to Grzywacz (2001), the principles of sustainable forest management have not been fully transferred from the technical-forestry principles and directives to detailed implementation instructions. In addition, the Polish model of forest management, despite the introduction of many elements respecting the principles of ongoing and sustainable development, cannot be considered multifunctional (Boulder 2003, 2007). The legal regulations and spatial planning practices in Poland do not contribute to establishing and further developing multifunctional forestry. In planning, the forest is treated mainly as an element of the administrative procedures required to locate an investment (Przybylska, Zięba 2009).

According to many authors (Rykowski 2011; Zięba, Przybylska 2015), a coherent and comprehensive planning system is needed to implement the sustainable forestry model and to develop a multifunctional forest. This system should take into account the prevailing legal principles, premises and determinants of socio-economic development as well as the directions and tasks of the broadly understood state forest policy. The key to long-term planning is to develop a concept that identifies the priority functions of forest management and allows strategic objectives to be allocated, while at the same time taking into account the spatial diversity of natural and socio-economic phenomena (Zięba, Przybylska 2015). According to Grzywacz (2001) and Rykowski (2011), it is important to prepare a National Forest Program in order to emphasize the compliance of forest planning with the legal foundations of the state and international obligations regarding sustainable forest management. Kaliszewski (2018) emphasises that despite the profound changes in the socio-economic, legal and institutional environment of forestry, the 'Forest Policy of the State' (MOŚZNiL 1997) has not been revised. A de-

Table 1. Values of the synthetic index *Z* in regional directorates of State Forests and their distribution into groups in the years: 1993, 1998, 2003, 2008, 2013

Regional directorates of State Forests	Synthetic index Z	Ranking and group		Synthetic index Z	Ranking and group		Synthetic index Z	Ranking and group		Synthetic index Z	Ranking and group		Synthetic index Z	Ranking and group	
	1993			1998			2003			2008			2013		
Białystok	0.462	4	II	0.438	5	II	0.508	2	I	0.507	4	II	0.483	2	II
Gdańsk	0.415	7	II	0.427	9	II	0.42	9	II	0.426	10	II	0.399	10	III
Katowice	0.502	2	I	0.428	8	II	0.415	12	II	0.441	9	II	0.39	12	III
Kraków	0.586	1	I	0.611	1	I	0.594	1	I	0.649	1	I	0.667	1	I
Krosno	0.465	3	II	0.434	7	II	0.449	4	II	0.516	2	II	0.468	4	II
Lublin	0.328	16	IV	0.376	14	III	0.385	13	III	0.358	14	III	0.356	15	III
Łódź	0.405	9	II	0.407	10	III	0.415	11	II	0.398	12	III	0.367	14	III
Olsztyn	0.408	8	II	0.382	12	III	0.421	7	II	0.445	8	II	0.404	9	III
Piła	0.349	13	III	0.377	13	III	0.251	17	IV	0.286	16	IV	0.288	16	IV
Poznań	0.417	6	II	0.443	3	II	0.42	8	II	0.446	6	II	0.426	8	II
Radom	0.428	5	II	0.443	4	II	0.417	10	II	0.516	3	II	0.479	3	II
Szczecin	0.337	14	III	0.386	11	III	0.435	5	II	0.446	7	II	0.455	6	II
Szczecinek	0.333	15	III	0.326	15	IV	0.326	14	III	0.295	15	IV	0.393	11	III
Toruń	0.404	10	II	0.483	2	I	0.482	3	II	0.457	5	II	0.451	7	II
Warszawa	0.401	11	III	0.309	17	IV	0.295	15	IV	0.383	13	III	0.372	13	III
Wrocław	0.398	12	II	0.434	6	II	0.423	6	II	0.416	11	III	0.456	5	II
Zielona Góra	0.238	17	IV	0.316	16	IV	0.270	16	IV	0.245	17	IV	0.248	17	IV
Avg	0.404	0.069		0.413	0.083		0.407	0.088		0.425			0.418		
SD	0.075						0.094								

Group: I – very high level of change, II – high level of changes, III – average level of changes, IV – low level of changes

tailed analysis of the need for change in the country's forest policy was made within the framework of the National Forest Program being prepared (Gołos et al. 2014; Kaliszewski, Rykowski 2015; Zając, Rykowski 2015). Currently, the aim is to develop global standards for assessing sustainable forest management, reflected, among others, in the premises of certification systems for the evaluation of sustainable forest management. In recent years, forestry experts have attempted to develop and update global forest indicators to track changes in key dimensions of sustainable development. It is recommended that sustainability indicators should not just be a reporting and monitoring tool, but a helpful tool in developing documents of strategic importance (www.fao.org.).

The values of sustainable forest management indicators in Poland are favourable in comparison to the results obtained by many countries in Europe and the world, which, however, should not weaken the motivation for further activity in this area. In 1990, the area of forests in the world was 4128 million ha, while in 2015 it decreased to 3999 million ha (FAO 2015). On the other hand, the rate of the loss of forest areas decreased, the indicator reflecting the loss of natural forest areas decreased from 8.5 million ha/year in 1990−2000 to 6.6 million ha/year in 2010−2015. Forests protecting water and soils constituted 25% of the forest area in the world. Over the past 25 years, global carbon stocks in forest biomass have decreased by about 17.4 (Gt), which was due to a change in the use of forest land for other purposes. However, the area of forests to be managed by plans increased; from 27% in 1953 to 70% in 2010 (FAO 2015). In addition, in 2014, almost 90% of temperate and boreal forests were certified. In the forests managed by the State Forests National Forest Holding in 1993−2013, a favourable rate of change was observed, reflecting the progress in sustainable forest management (Kożuch et al. 2018). Most of the diagnostic variables adopted for the analysis had positive values and

were characterised by increases, also against the backdrop of the European Union (EU) countries. The dynamics of change were positive over the twenty years in the most important areas of forestry, that is, (1) forest resources, (2) health and vitality of forest ecosystems, (3) production functions of forests, (4) protection, enriching the biological diversity and habitat-creation functions of forests, and (5) socio-economic functions of forests (Kożuch et al. 2018). This also reflects the ever-faster pace of change and the involvement of forest supervisors and managers in the process of the sustainable development of forestry in Poland. The analyses performed by Rykowski (2006) and Zając et al. (2014) reflected the positive direction of change in Polish forestry, also compared to the other EU countries. The large share of protected areas and the important role of the forest in creating jobs were pointed out. In terms of abundance, the Polish forests are among the European leaders, the average forest resource abundance in Europe (131 m^3/ha) is almost two-times lower than the average forest resource abundance in Poland (247 m^3/ha) (SoEF 2011). Poland ranks sixth among the European countries in terms of timber harvesting (Rykowski 2006). The threat of fires and the necessity to tend to forests' health condition are constantly emphasised. Efforts must also be undertaken to increase the area of naturally regenerating forests, because Poland's level remains at the lowest among the European countries (OECD 2015).

5. Summary

The State Forests regional directorates are strongly diversified in terms of the pace of change taking place in their districts in sustainable forest management. The most favourable conditions in the analysed period were found in the rdSFs of Kraków, Toruń and Białystok. The least favourable situations from the point of view of the analysed phenomena were in the rdSFs of Zielona Góra, Piła and Warsaw. In 1993−1998, the synthetic index (*Z*) had the highest dynamics in the Zielona Góra and Toruń rdSFs, and the lowest in the Katowice and Warsaw rdSFs. In turn, in 2008−2013, the highest rate of change was found in the rdSFs of Szczecinek and Wrocław, and the lowest in the rdSFs of Krosno and Katowice. The desired level and/or increase in the value of sustainable development indicators obtained over time should be the basic criterion for positively assessing the management of SF units.

The diversity of the country's regions in terms of the perspectives for developing and implementing the principles of sustainable development results mainly from natural and economic conditions, as well as from historical, legal and social conditions. However, despite numerous limitations, for example, the environmental ones, forest managers have considerable opportunities to shape and perform the management of forests in accordance with the principles of sustainable development.

Assessing the activities of the SF regional directorates in terms of implementing the principles of sustainable development in forestry is a complex task, requiring the consideration of many factors. Sustainability indicators seem to be a good instrument for measuring the rate of change in forest management. They are an effective tool for assessing and reporting progress over time. They should also be used when planning and preparing strategically important documents. It is worth continuing work on the methodology and selection of indicators, serving as a reliable, objective and spatiotemporally comparable evaluation tool.

Conflict of interest

The authors declare no potential conflicts of interest.

Acknowledgment and source of funding

The research was financed by a grant from the Ministry of Science and Higher Education for statutory activities.

References

Barzdajn W., Ceitel J., Zientarski J. 1997. Wyróżniki leśnictwa wykorzystującego i chroniącego przyrodę. *Sylwan* 141(4):119–127.

Binderman Z., Borkowski B., Szczęsny W. 2009. O pewnych metodach porządkowania i grupowania w analizie zróżnicowania rolnictwa. *Roczniki Nauk Rolniczych. Seria G: Ekonomika Rolnictwa* 96(2): 77–90.

Borkowski B., Dudek H., Szczęsny W. 2007: Ekonometria. Wybrane zagadnienia. PWN, Warszawa. ISBN 978-83-01152-91-8.

Borkowski B., Dudek H., Szczęsny W. 2006. O pewnym problemie przekształcania cech. *Acta Agraria et Silvestria, Seria Agraria, Sekcja Ekonomiczna* 47: 47–89.

Borys T. 1978. Propozycje agregatowej miary rozwoju obiektów. Przegląd statystyczny, z. 3.

Borys T. 1999. Wskaźniki ekorozwoju. Wydawnictwo Ekonomia i Środowisko. Białystok. ISBN 8385792589.

FAO 2015. Global Forest Resources Assessment. How are the world's forests changing? Food and Agriculture Organization of the United Nations. Rome.

Głaz J. 2003. Kryteria i wskaźniki trwałej i zrównoważonej gospodarki leśnej w planowaniu urządzeniowym. *Biblioteczka Leśniczego* 184: 3–18.

Głaz J. 2007. Zasady funkcjonowania zrównoważonego gospodarstwa leśnego na przykładzie regionu uprzemysłowionego. *Prace Instytutu Badawczego Leśnictwa. Rozprawy i Monografie*, IBL, Sękocin Stary. ISBN 978-83-87647-63-6.

Gołos P., Kaliszewski A., Rykowski K. (red. nauk.) 2014. Materiały drugiego panelu ekspertów w ramach prac nad Narodowym Programem Leśnym. Wartość. Lasy jako czynnik rozwoju cywilizacji: współczesna i przyszła wartość lasów. Instytut Badawczy Leśnictwa, Sękocin Stary, 1–310. ISBN 978-83-62830-34-3.

Grzywacz A. 2001. Podstawy prawne trwale zrównoważonej gospodarki leśnej. *Roczniki Akademii Rolniczej w Poznaniu, Leśnictwo* 39: 93–107.

Kaliszewski A., Rykowski K. (red. nauk.) 2015. Materiały piątego panelu ekspertów w ramach prac nad Narodowym Programem Leśnym. Rozwój. Lasy i gospodarka leśna jako instrumenty ekonomicznego i społecznego rozwoju kraju. IBL, Sękocin Stary, 1–363. ISBN 978-83-62830-44-2.

Kaliszewski 2018. Cele polityki leśnej w Polsce w świetle aktualnych priorytetów leśnictwa w Europie. Część 1. Procesy kształtujące politykę leśną w Europie. *Leśne Prace Badawcze* 79(1): 77–87. DOI 10.2478/frp-2018-0009.

Konstytucja 1997. Konstytucja Rzeczypospolitej Polskiej z dnia 2 kwietnia 1997 r. Dz.U. 1997 nr 78 poz. 483.

Kożuch A., Banaś J., Zięba S., Ryś M., Zaborski K., Adamowicz K. 2018. Zastosowanie wskaźników zrównoważonego rozwoju do oceny dynamiki zmian zachodzących w lasach w latach 1993–2013. *Acta Scientiarum Polonorum Silvarum Colendarum Ratio et Industria Lignaria* 17(1): 25–34.DO I10.17306/J.AFW.2018.1.3.

Kukuła K. 2000. Metoda unitaryzacji zerowanej. PWN, Warszawa. ISBN 8301130970.

Młodak A.2006. Analiza taksonomiczna w statystyce regionalnej. Difin, Warszawa. ISBN 83-7251-605-7.

Nowak E. 1990. Metody taksonomiczne w klasyfikacji obiektów społeczno-gospodarczych. PWE, Warszawa. ISBN 832-08-0689-5.

OECD2015. OECD Environmental Performance Reviews: Poland 2015, OECD Publishing. http://dx.doi.org/10.1787/9789264227385-en [10.12.2017].

Przybylska K., Zięba S. 2009. Las i gospodarka leśna w systemie planowania i zagospodarowania przestrzennego w Polsce. *Sylwan* 153(12): 814–824.

Rykowski K. 2006. O leśnictwie trwałym i zrównoważonym. W poszukiwaniu definicji i miar. CILP, Warszawa. ISBN 978-83-89744-19-7.

Rykowski K. 2011. Czy istnieje trwale zrównoważona, wielofunkcyjna gospodarka leśna? W: Wartości nierynkowych korzyści z lasów. Metody wyceny oraz zastosowanie wyników w analizach ekonomicznych. Materiały konferencyjne Polforex, Warszawa, 117–140.

State of Europe's Forests (SoEF) 2011. Status and Trends in Sustainable Forest Management in Europe 2011. MCPFE, Forest Europe Liaison Unit, Oslo.

Szujecki A. 1995. Ochrona zagospodarowanych ekosystemów leśnych w warunkach niepewności. *Sylwan* 139(1): 5–18.

Szujecki A. 1997. Leśnictwo a wyzwania cywilizacyjne XXI w. *Przyroda Polska* 5: 24–25.

Szymański S. 1997. Znaczenie długoterminowych badań naukowych w ekologii i hodowli lasu. *Sylwan* 141(4): 5–9.

Walesiak M. 2004. Modelowanie ekonometryczne zjawisk marketingowych. *Prace Naukowe Akademii Ekonomicznej we Wrocławiu. Ekonometria* 1021(14): 23–36.

Zając S., Kaliszewski A., Młynarski W. 2014. Forests and forestry in Poland and other EU countries. *Folia Forestalia Polonica, series AForestry*56(4): 185–193. DOI 10.2478/ffp-2014-0021.

Zając S., Rykowski K. (red. nauk.) 2015. Materiały siódmego panelu ekspertów w ramach prac nad Narodowym Programem Leśnym. Współdziałanie. Lasy i gospodarka leśna jako międzysektorowe instrumenty rozwoju. Instytut Badawczy Leśnictwa, Sękocin Stary, 1–217. ISBN 978-83-62830-50-3.

Zięba S., Przybylska K. 2015. Społeczno-gospodarcze uwarunkowania budowy regionalnych strategii zrównoważonej gospodarki leśnej,w: Panel ekspertów: Współdziałanie. Las i gospodarka leśna jako międzysektorowe instrumenty rozwoju.Instytut Badawczy Leśnictwa, Sękocin Stary.http://www.npl.ibles.pl/wspoldzialanie [20.06.2015].

List of sources

BULiGL 2010. Wielkoobszarowa inwentaryzacja stanu lasów. Wyniki I cyklu (lata 2005–2009). Sękocin Stary, Biuro Urządzania Lasu i Geodezji Leśnej.

BULiGL 2014. Wielkoobszarowa inwentaryzacja stanu lasów w Polsce. Wyniki za okres 2009–2013. Sękocin Stary, Biuro Urządzania Lasu i Geodezji Leśnej.

DGLP 2004. Raport z działalności edukacyjnej Lasów Państwowych w 2003 roku. Warszawa, Dyrekcja Generalna Lasów Państwowych.

DGLP 2009. Raport z działalności edukacyjnej Lasów Państwowych w 2008 roku. Warszawa, Dyrekcja Generalna Lasów Państwowych.

DGLP 2014. Raport z działalności edukacyjnej Lasów Państwowych w 2013 roku. Warszawa, Dyrekcja Generalna Lasów Państwowych.

GUS 1994. Leśnictwo 1994. Warszawa, Główny Urząd Statystyczny.

GUS 1999. Leśnictwo 1999. Warszawa, Główny Urząd Statystyczny.

GUS 2004. Leśnictwo 2004. Warszawa, Główny Urząd Statystyczny.

GUS 2009. Leśnictwo 2009. Warszawa, Główny Urząd Statystyczny.

GUS 2014. Leśnictwo 2014. Warszawa, Główny Urząd Statystyczny.

MOŚZNiL 1997. Polityka leśna państwa. Dokument przyjęty przez Radę Ministrów w dniu 22 kwietnia 1997 r. Ministerstwo Ochrony Środowiska Zasobów Naturalnych i Leśnictwa, Warszawa.

MŚ 2008. Polityka ekologiczna Państwa w latach 2009–2012 z perspektywą do roku 2016. Ministerstwo Środowiska, Warszawa.

RDLP 2004. Regionalny Program Operacyjny Polityki Leśnej Państwa (RPO) 2004. Regionalna Dyrekcja Lasów Państwowych w Zielonej Górze. www.npl.ibles.pl/sites/default/filesustawy/zielona_gora.pdf [12.03.2018].

Ustawa 1991. Ustawa z dnia 28 wrzesień 1991 r. o lasach(z późniejszymi zmianami). Tekst jednolity na podstawie obwieszczenia Ministra Środowiska w DZ.U. z 2000 r. Nr 56, poz. 679.

www.fao.org/forestry/ci/91809/en [12.06.2017].

Author's contribution

A.K. – literature review, concept, methodology, collecting and analysing data, preparation of the manuscript – research results, discussion; J.B., S.Z., L.B. – collecting and analysing data, manuscript corrections.

Translated by: Barbara Przybylska