Bulletin of Geography. Physical Geography Series, No. 8 (2015): 123–132
http://dx.doi.org/10.1515/bgeo-2015-0010

Structure and importance of soil-protecting forests in the areas administered by the RDSF Toruń

ISSN 2080-7686

Paweł Wiśniewski, Mariusz Kistowski

University of Gdańsk, 80-952 Gdańsk, Poland

Correspondence: Paweł Wiśniewski, Department of Physical Geography and Environmental Management, Institute of Geography, University of Gdańsk, Bażyńskiego 4, 80-952 Gdańsk, Poland. E-mail: p.wisniewski@ug.edu.pl

Abstract. The paper presents the state and importance of soil-protecting forests in the areas managed by the RDSF in Toruń, as well as changes in their structure over 29 years. The management of the RDSF in Toruń is characterized by a systematic increase in the area, thickness and rich abundance of soil-protecting forests, particularly intense since the mid-nineteen-nineties. They cover mainly rusty soils and podzols on outwash areas, sandy terraces in sloped areas of postglacial valleys and gullies as well. Soil-protecting forests, which are managed by the RDSF in Toruń, vary a great deal considering their habitat, both in terms of dampness and trophic richness as well as spatially. The dominance of coniferous forests is due to the fact that they grow in the poorest habitats, which have not been previously used for agricultural purposes, and to the common practice in recent years of pine reforestation in open stromal areas. The assessment of the state of habitats indicates that 66.2% of the soil-protecting forest area is characterized as natural and close-to-natural. Distorted or transformed habitats occupy 26.2% of the soil-protecting forest area, while the degraded habitats 7.6%. Taking the study area into consideration we can observe the relationship between the incompatibility of habitat in its natural form and the post-arable feature. Changes in habitat characteristics are shown by 75.5% of the area of the soil-protecting forest located on former farmland, mainly in the areas with rusty podzolic soils (Albic Brunic Arenosols). Incompatibility of the habitats is, among others, the result of the creation in recent years, during the afforestation of agricultural lands, of solid pine stands, also in fertile habitats. Secondary planted pine monocultures in the forest areas resulted in podzolization of rusty soils and transformed them into rusty podzolic soils.

Key words
soil-protecting forest,
forest structure,
soil protection,
RDSF Toruń

Introduction

The perception of the role of the forest in the environment and human life has been changing with the development of civilization. In some countries, its protective function started to be noticed very early. For example, in France as early as 1520, a special decree introduced a ban on grubbing-up forests located less than six miles from the River Seine and its tributaries. Napoleonic legislation forbade deforestation on slopes and mountain peaks (Nowakowska 2008). A clear separation of the three groups of forest functions – productive, economic and protective – occurred in the 1930s (Klocek 2003).

In Poland, the inclusion of non-production activities in forestry found formal expression, for the first time, in the principles of forest management in the National Forest Holding, issued by the Ministry of Forestry in 1955 (Zajączkowski 2003). Two years later, the division into commercial forests (group II) and protective (group I) appeared, for the first time in the history of Polish forestry, in the Forest Management Manual (1957).

The Forests Act (1991), which came into force in 1992, was a sign of change in the state's approach

to forests and allowed the purposes of forestry to be extended and unified, regardless of the ownership of the forests (Klocek 1999; Geszprych 2009). The Act enabled recognition for protection, among others, of forests that protect the soil from washing or erosion and restrain landslides, rock falls or avalanches. Soil protection has also been included in the National Forest Policy (1997).

The aim of the study is to assess the status and importance of forests legally recognized as soil-protecting, in areas managed by the Regional Directorate of State Forests (RDSF) in Toruń, as well as the changes that occurred in their structure in the years 1985–2013.

Material and Methods

In order to identify and recognize the status and importance of soil-protecting forests, within the study area a spatial analysis was conducted, using data provided by the RDSF in Toruń, the database of the Information System of National Forests, information layers of digital maps made using ArcGIS software (v.9.3), as well as the development of components and evaluation reports on the soil and habitat of forest superintendence. Species composition was evaluated as well as the age structure of forests, habitat types and the condition of forest habitats, as well as kinds and types of soil, and the participation of former farmland in the soil-protecting forest. In order to determine the ability of forests to perform functions assigned to them in accordance with the theoretical basis for assessing the sustainability of the forest as a natural system, proposed by Miś (2007), the relationship between the state of selected aspects of soil-protecting forests was analysed: the age of the forests and their growing stock and abundance as well as the difference between the type and condition of habitats and the share of a particular type of tree. The Pearson correlation r coefficient was computed between soil-protecting forest site types and the main tree species in the RDSF in Toruń.

Based on the results of updates on the forest area and forest resources in the State Forests, made by the Bureau of Forest Management and Geodesy, the change in the structure and growing stock of the surface of soil-protecting forests over the period 1985–2013 was determined. In the analysis, the organizational transformation of National Forests related to the change of the political system and the entry into force of the Forest Act was included.

Results and Discussion

In the years 1985-2013 the area of forests administered by the RDSF in Toruń increased from 407.1 thousand ha to 421.5 thousand ha (Państwowe Gospodarstwo Leśne… 2014). The decrease in the area of forest land which performs a productive function was accompanied by a systematic increase in the importance of forests with dominant protective functions. Against the background of all regional directorates, the RDSF in Toruń has the highest increase in the area of soil-protecting forest (Fig. 1), particularly intense since the second half of the 1990s. During the period considered, in the RDSF in Toruń, the largest in The State Forests National Forest Holding scale, a 20-fold increase in thickness and a 55% increase in the average growing stock of the soil-protecting forests, were recorded (Figs 2 and 3).

The largest soil-protecting forest complexes are located in the central, northern and south-eastern part of the study area (Fig. 4), on the outwash areas and sandy terraces endangered by wind erosion as well as on mountainsides highly exposed to water erosion such as Toruń-Eberswalde ice-marginal valley and the Valley of the Lower Vistula. More than 80% of their area is located within the boundaries of forest inspectorates covering the areas extending along the Central Noteć Valley, Toruń and Płock Basins, Fordon Valley and Grudziądz Valley (Figs 5 and 6). The share of soil-protecting forests in the total forest area of each of the forest inspectorates varies greatly. In most cases, this is less than 5%, ranging from 0.1% in the Tuchola Forest Inspectorate to 68.7% in the Gniewkowo Forest Inspectorate (Fig. 7).

The data analysis of the derived forest layers of digital maps, relating to particular habitat precipitates, shows that the land on which the soil-protecting forests were designated is characterized by a great diversity of soil conditions. The greatest per-

 Citation: Bulletin of Geography. Physical Geography Series 2015, 8, http://dx.doi.org/10.1515/bgeo-2015-0010

centage is taken by the areas with rusty podzolic soils (Albic Brunic Arenosols), proper podzol (Entic Podzols) and proper rusty soils (Brunic Arenosols). Among the soil types, sands, which are prone to stripping and leaching, are predominant: eolian (partly dune formations), river Pleistocene terraces and fluvioglacial, occupying a total of 84.7% of land area under soil-protecting forests (Table 1). The results of studies on the effectiveness of soil-protecting forest in counteracting the negative effects of erosion and soil degradation in moraine areas of lake districts are shown in previous works of the co-author (Wiśniewski 2012; Wiśniewski, Wojtasik 2012, 2014).

Table 1. The share of soil types and kinds under soil-protecting forests in the areas administered by the RDSF Toruń (as of 2010)

Soil type*	Area		Soil kind*	Area	
	ha	%		ha	%
Rusty podzolic soils	26128.34	51.33	Eolian sands	12382.91	24.33
Proper podzol soils	9013.31	17.70	Dune sands	12032.67	23.64
Proper rusty soils	5459.86	10.73	Pleistocene river (terraces) sands	11104.19	21.81
Rusty brown soils	3039.08	5.97	Fluvioglacial sands	7582.04	14.90
Proper arenosols	1095.54	2.15	Boulder sands	2652.98	5.21
Brown deluvial soils	707.84	1.39	Boulder clays	1808.71	3.55
Leached brown soils	665.75	1.31	Deluvium	1366.54	2.68
Muckous soils	577.15	1.13	Peats	605.93	1.19
Typical brown soils	556.30	1.09	Fluvioglacial sands on boulder clays	387.65	0.76
Soils lessivés	462.16	0.91	Holocene river sands	383.44	0.75
Brown soils lessivés	417.22	0.82	Moorsh	115.45	0.23
Podzolized arenosols	404.69	0.80	Alluvial fan sands	114.56	0.23
Peat-muck soils	289.12	0.57	Fluvisols	101.42	0.20
Low peat soils	222.36	0.44	Anthropogenic deposits	98.12	0.19
Proper deluvial soils	187.16	0.37	Lacustrine sands	56.16	0.11
Proper gley-podzol soils	144.72	0.28	Calcareous gyttja and lacustrine chalks	39.98	0.08
Mucky gley-podzol soils	134.56	0.27	Mucks and organic gyttja	36.14	0.07
Acid brown soils	132.59	0.26	Varved clays	26.64	0.05
Humous deluvial soils	124.34	0.24	Glaciolacustrine and sandy silt deposits	5.97	0.01
Other	1139.91	2.24	Other	0.5	<0.01
Total	50902	100	Total	50902	100

Explanations: * According to Classification of Polish forest soils (Biały et al. 2000)

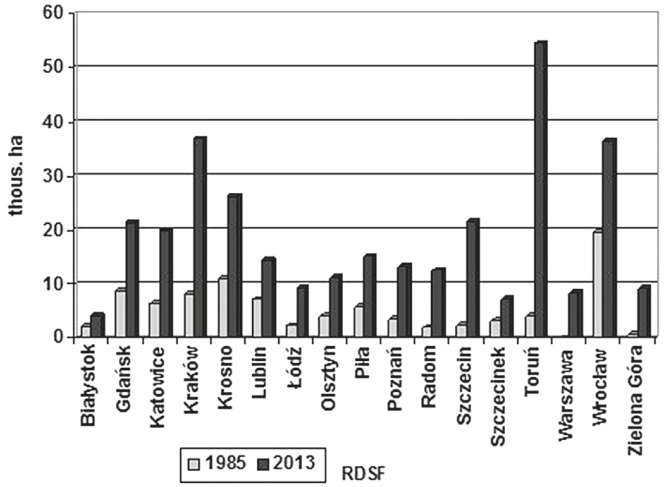

Fig. 1. Changes in the soil-protecting forest cover by RDSF in the years 1985––2013

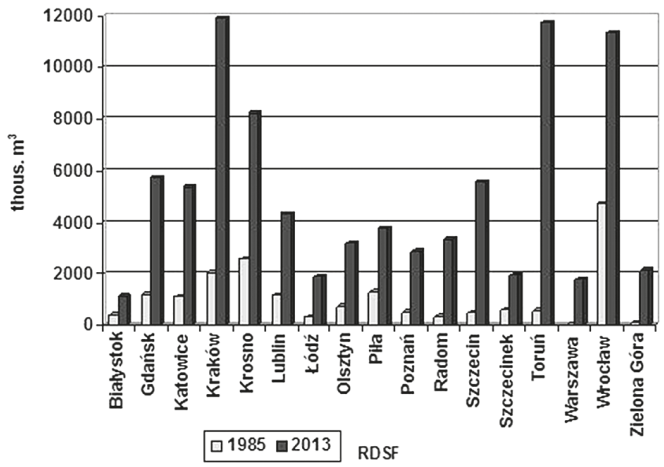

Fig. 2. Changes in the soil-protecting forests growing stock by RDSF in the years 1985–2013

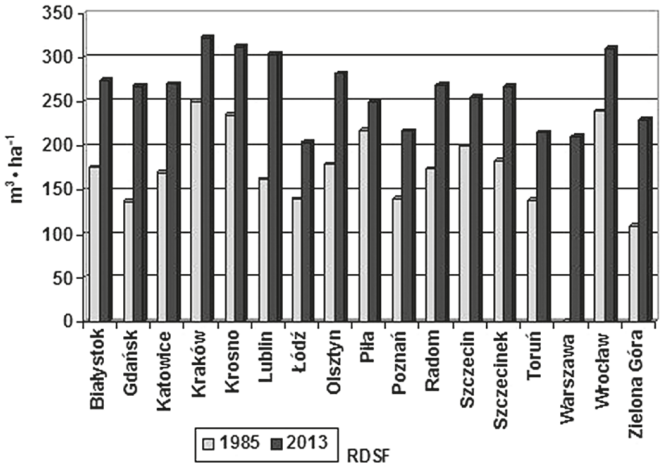

Fig. 3. Changes in the average stem volume of the soil-protecting forests by RDSF in the years 1985–2013

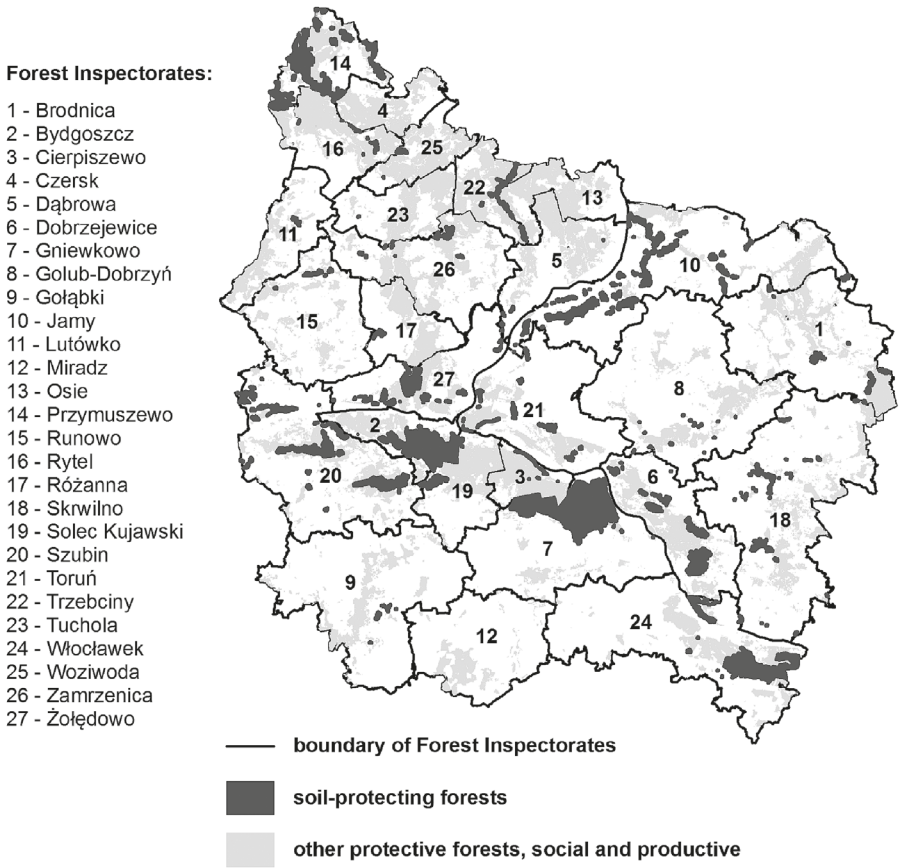

Fig. 4. Spatial distribution of soil-protecting forests in the RDSF Toruń in 2010

Fig. 5 The soil-protecting forest in the escarpment zone of the Toruń-Eberswalde ice-marginal valley (photo by P. Wiśniewski, August 2010)

Fig. 6. The soil-protecting forest in the agricultural landscape of the undulated morainic plateau in the Krajna Lakeland (photo by P. Wiśniewski, August 2010)

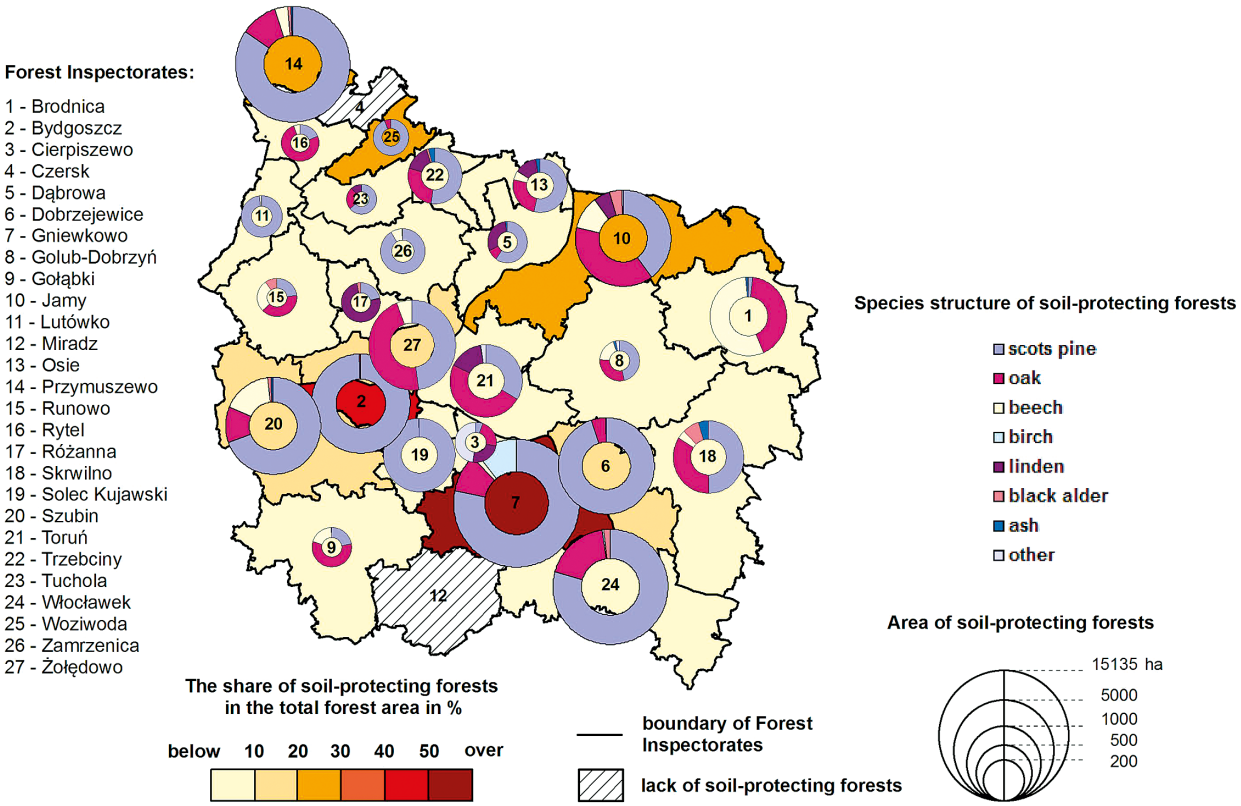

Fig. 7. Species structure and the share of soil-protecting forests in total forest area by Forest Inspectorates of the RDSF Toruń in 2010

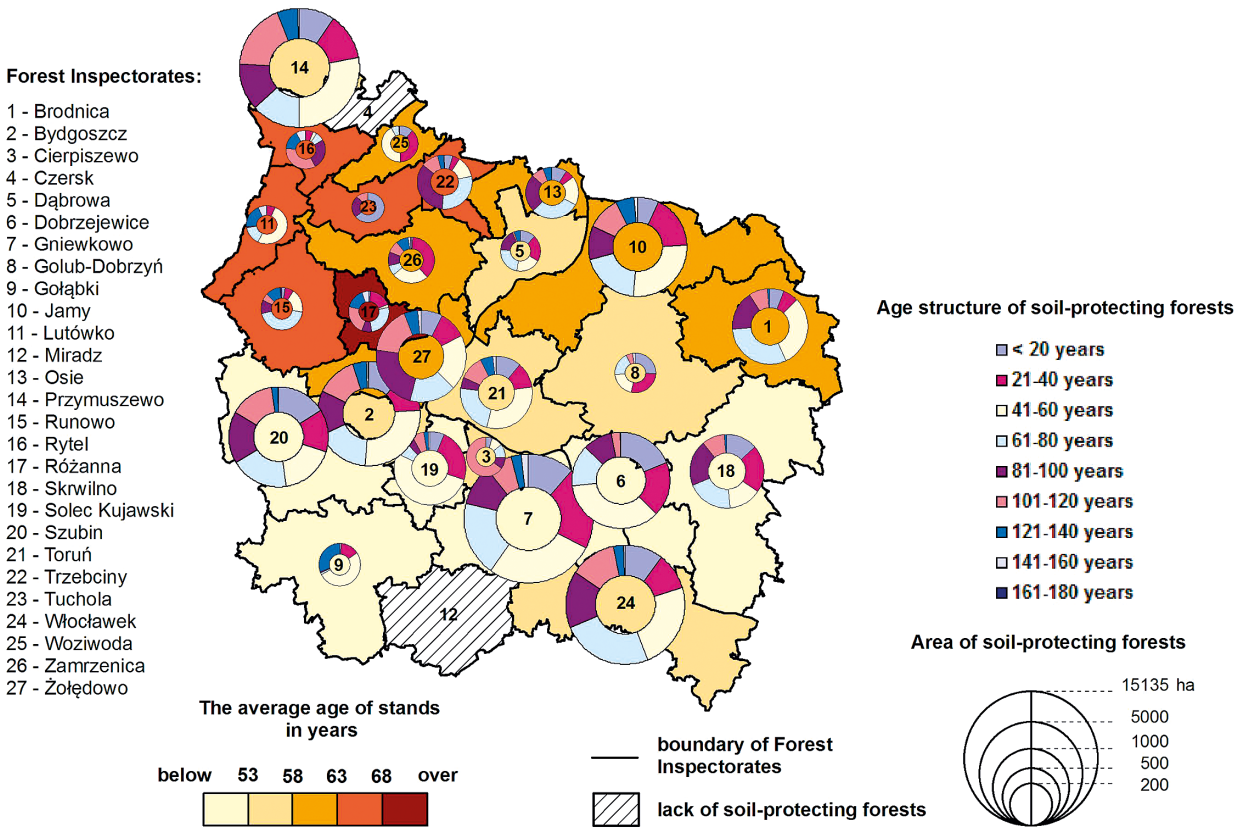

Fig. 8. Age structure of soil-protecting forests by Forest Inspectorates of the RDSF Toruń in 2010

Soil-protecting forests, which are managed by the RDSF in Toruń, vary a great deal considering their habitat, both in terms of dampness and trophic richness (trophic) as well as spatial. The greatest share is occupied by coniferous forests, 28.9% of the soil-protecting forest area, and mixed forests (28%). Slightly smaller areas are occupied by forest site type (21.6%) and mixed coniferous forests (20.4%). The lowest share (1.1%) is taken by riparian forests. The dominance of coniferous forests is due to the fact that they grow in the poorest habitats, which have not been previously used for agricultural purposes and to the common practice in recent years of pine reforestation in open stromal areas (Wysocki, Sikorski 2009). In terms of dampness, the largest share is taken by the fresh habitats, which totally occupy 95% of the soil-protecting forest area. Wetland habitats are represented mainly by moist forest, associated with a rather shallow level of groundwater or a strong influence of periodic stagnant rainwater. Among the marshland habitats, the largest areas are occupied by marsh forest associated with cavities and depressions of terrain, marshy valleys of watercourses and lake basins, as well as marshy riparian forest, characteristic of floodplains, natural levees of smaller watercourses and banks of lake basins (Dyrekcja Generalna… 2004). Extremely poor and dry habitat is occupied by dry coniferous forests with a very deep level of ground waters, characterized by pine trees and shrubs or grass-and-mossy undergrowth.

A proper adaptation of the local forest vegetation to the local habitat conditions has an impact on the soil-forming processes and the effectiveness of the protective role of the forest. Inappropriate composition of vegetation may contribute to degradation changes, in particular a decrease in biological activity, leaching of nutrients and soil acidification (Jakubowski 1994). Based on the assessment of the relationship between the state of the selected aspects of soil-protecting forests, their relative stability was ascertained. The assessment of the state of habitats indicates that 66.2% of the soil-protecting forest area is characterized as natural and close-to-natural, displaying the maintenance of ecological balance. Properties of the upper soil layers, type of humus, trees and undergrowth are, in such cases, unchanged and in accordance with the natural habitat conditions. Distorted or transformed habitats occupy 26.2% of the soil-protecting forest area, while the degraded habitats – 7.6%. They are characterized by unfavourable artificial changes, decreased fertility, poorer properties of the upper layers of the soil and changes in plant communities.

Taking the study area into consideration we can observe the relationship between the incompatibility of habitat in its natural form and the post-arable feature, which is characteristic for almost 14 thousand ha (27.4%) occupied by the soil-protecting forests. Changes in habitat characteristics are shown by 75.5% of the area of the soil-protecting forest located on former farmland. In the case of land having no features of post-agricultural activities, the share reaches 18.1%. Post arable habitats are often characterized by (especially in the first generation of the forest) plow sole, preserved in the soil, improperly shaped organic level, elevated pH indicator, unsettled quantitative ratio of minerals and the lack of developed symbiotic systems (Państwowe Gospodarstwo Leśne… 2003). Incompatibility of the habitats is, among others, the result of the creation in recent years, during the afforestation of agricultural lands, of solid pine stands, also in fertile habitats. An analysis of the species composition of soil-protecting forests on former farmland within the Directorate of Toruń shows that the current productivity of these habitats is often reduced by one or two types of habitat in relation to the potential productivity. In accordance with the afforestation of post-agricultural lands species composition approximated that given in principles of silviculture (Państwowe Gospodarstwo Leśne… 2012). In the Baltic and Wielkopolska-Pomerania Natural-Forest Regions, pine can be the dominant species in, inter alia, dry coniferous forests, fresh coniferous forests and fresh mixed coniferous forests. Meanwhile, in the RDSF in Toruń it is also the dominant species in the fresh mixed forests and fresh forests. As pointed out by Puchniarski (2000) it is the result, since the beginning of the 1990s, of ongoing uncoordinated afforestation, which is not related to local zoning plans.

Bednarek et al. (2009) and Świtoniak et al. (2014), assessing anthropogenic transformation of soil cover in the chosen types of the young glacial relief, suggest that secondary planted pine monocultures in the forest areas resulted in podzolization of rusty soils and transformed them into

rusty podzolic soils (Albic Brunic Arenosols). In the RDSF in Toruń it is a frequent phenomenon so proper rusty soils (Brunic Arenosols) without podzolization features occupy only 10.7% of land area under soil-protecting forests, which is shown in detail in previous work of the author (Wiśniewski 2012).

The RDSF in Toruń is characterized by a high share of pine and larch in the surface structure of dominant species in Poland, which is 86.8% (Państwowe Gospodarstwo Leśne... 2014). In the case of soil-protecting forests, the share of coniferous species, represented almost exclusively by scots pine, is slightly lower, 75%. The spatial distribution of species in stands of the Toruń Directorate of State Forests is varied. Forest inspectorates located in the northern and central parts of the study area, on sandur plains and sandy terraces, have a clear dominance of coniferous stands. In the Forest Inspectorates Solec Kujawski and Bydgoszcz, located within the borders of the eolian-transformed Toruń Basin, the share of pine in the species structure of soil-protecting forests is over 99%. Areas located in the eastern, western and southern parts of the RDSF in Toruń are characterized, however, by a higher proportion of deciduous species. In the Brodnica Forest Inspectorate deciduous stands occupy 97.9% of the soil-protecting forest area, of which 55.5% is beech, and 41.7% is oak tree. A high proportion of deciduous species in the soil-protecting forests is also characteristic for Forest Inspectorates Cierpiszewo (94.4%) and Rytel (81.1%). Statistical analysis covering the main tree species and forest types of habitats showed that in the soil-protecting forests, there are clear positive correlations, in particular between the share of the surface of coniferous forests and Scots pine as well as birch, mixed forests, oak, beech, and black alder, as well as riparian forests and elm and alder (Table 2). The analysis did not show a clear negative correlation between these elements of soil-protecting forests.

Table 2. Pearson's correlation coefficient between soil-protecting forest site types and the main tree species in the RDSF Toruń (as of 2010)

Main species	Forest site type				
	Coniferous forests	Mixed coniferous forests	Broad-leaved mixed forests	Broad-leaved forests	Riparian forests
Beech	0.12	0.52	0.68	0.88	0.69
Birch	0.82	0.57	0.47	0.07	-0.01
Oak	0.53	0.74	0.92	0.72	0.67
Hornbeam	-0.13	-0.16	-0.11	-0.09	-0.11
Ash	0.01	0.41	0.17	0.35	0.27
Linden	-0.16	0.00	0.58	0.61	0.75
Larch	0.31	0.02	-0.16	-0.15	-0.11
Black alder	0.05	0.44	0.69	0.81	0.87
Scots pine	0.98	0.88	0.49	0.22	0.13
Spruce	-0.14	-0.18	-0.06	-0.06	-0.10
Elm	-0.07	0.14	0.74	0.74	0.91

Explanations: significance level $p = 0.05$

The average age of stands of the RDSF in Toruń is 62 years and is identical to the national average (Państwowe Gospodarstwo Leśne... 2014). Compared with the State Forest average Toruń administration is characterized by a slightly higher share of stands V and older age classes (over 80 years), which covers 27.8% of the forest area. Considering only the soil-protecting forests, the average age of stands is lower, which is 58 years. The analysis of the surface structure by age class shows that medium stands (classes III and IV) have the highest share. The youngest stands (up to 40 years of age) occupy a total of 25.2%, while the oldest (V and older age classes) 32.7% of the soil-protecting forest area. The average age of stands is lowest in the forest inspectorates located in the southern part of the RDSF in Toruń, while the highest is in its northern part (Fig. 8), and ranges from 48 to 72 years. Among the various species, the highest average age is exhibited by hornbeam – 81

 Citation: Bulletin of Geography. Physical Geography Series 2015, 8, http://dx.doi.org/10.1515/bgeo-2015-0010

years; lime – 74 years; and oak – 64 years. The average age of pine stands, which have the greatest impact on the average age of the soil-protecting forests, is 60 years. Among the youngest species are elm – 36 years; larch – 37 years; and beech – 39 years.

Conclusions

1. The RDSF in Toruń has the largest area in the country of soil-protecting forest and the highest percentage share in the general forest resources.
2. The systematic increase in the area, growing stock and abundance of soil-protecting forest over the period of 29 years demonstrates the implementation of the concept of the multifunctional model of the forest by the State Forests National Forest Holding, with particular emphasis on its ecological role, whose main element is the protection of soils.
3. Secondary planted pine monocultures in the post-agricultural areas resulted in podzolization of rusty soils and transformed them into rusty podzolic soils (Albic Brunic Arenosols), which occupy over 51% of land area under soil-protecting forests in the areas administered by the RDSF Toruń.
4. In order to enhance soil-protecting functions of the forest, one should eliminate errors occurring in the past during the afforestation of post-agricultural lands, associated with inadequate matching of tree species to habitat conditions.

References

BEDNAREK R., DĄBROWSKI M., ŚWITONIAK M., 2009, Antropogeniczne przekształcenia pokrywy glebowej w wybranych typach rzeźby młodoglacjalnej na przykładzie gminy Jeżewo. Zeszyty Problemowe Postępów Nauk Rolniczych, 540: 139–146.

BIAŁY K., BROŻEK S., CHOJNICKI J., CZĘPIŃSKA-KAMIŃSKA D., JANUSZEK K., KOWALKOWSKI A., KRZYŻANOWSKI A., OKOŁOWICZ M., SIENKIEWICZ A., SKIBA S., WÓJCIK J., ZIELONY R., 2000, Klasyfikacja gleb leśnych Polski. Centrum Informacyjne Lasów Państwowych, Warszawa.

DYREKCJA GENERALNA LASÓW PAŃSTWOWYCH, 2004, Siedliskowe podstawy hodowli lasu, Załącznik nr 1 do Zasad hodowli i użytkowania lasu wielofunkcyjnego. Centrum Informacyjne Lasów Państwowych, Warszawa.

GESZPRYCH M., 2009, Specyfika nadzoru i sfera wartości w prawie leśnym. Studia Lubuskie, V: 159–181.

JAKUBOWSKI G., 1994, Lesistość a problemy ochrony środowiska. Postępy Techniki w Leśnictwie, 55: 65–71.

KLOCEK A., 1999, Pozaprodukcyjne funkcje lasu jako publiczne świadczenia gospodarki leśnej oraz stany jej równowagi. Sylwan, 143: 5–20.

KLOCEK A., 2003, Ekonomiczne aspekty leśnictwa w krajach Unii Europejskiej i w Polsce. Sylwan, 147: 1–11.

MINISTERSTWO LEŚNICTWA I PRZEMYSŁU DRZEWNEGO, 1957, Instrukcja urządzania lasu. Państwowe Wydawnictwo Rolnicze i Leśne, Warszawa.

MINISTERSTWO OCHRONY ŚRODOWISKA, ZASOBÓW NATURALNYCH I LEŚNICTWA, 1997, Polityka leśna państwa. Wydawnictwo Świat, Warszawa.

MIŚ R., 2007, Urządzanie lasów wielofunkcyjnych. Wydawnictwo Akademii Rolniczej im. Augusta Cieszkowskiego, Poznań.

NOWAKOWSKA J., 2008, Niektóre obszary leśne o specjalnym przeznaczeniu (funkcjach) w ujęciu historycznym. Studia i Materiały Centrum Edukacji Przyrodniczo-Leśnej, 3: 34–40.

PAŃSTWOWE GOSPODARSTWO LEŚNE LASY PAŃSTWOWE, 2003, Instrukcja urządzania lasu, część 2, Załącznik do Zarządzenia nr 43 Dyrektora Generalnego Lasów Państwowych z dnia 18 kwietnia 2003 r. Centrum Informacyjne Lasów Państwowych, Warszawa.

PAŃSTWOWE GOSPODARSTWO LEŚNE LASY PAŃSTWOWE, 2012, Zasady hodowli lasu. Centrum Informacyjne Lasów Państwowych, Warszawa.

PAŃSTWOWE GOSPODARSTWO LEŚNE LASY PAŃSTWOWE, 2014, Wyniki aktualizacji stanu powierzchni leśnej i zasobów drzewnych w Lasach Państwowych na dzień 1 stycznia 2013 roku. Oficyna Wydawnicza Forest, Józefów.

PUCHNIARSKI T.H., 2000, Krajowy program zwiększania lesistości. Zalesienia porolne. Poradnik od A do Z. Państwowe Wydawnictwo Rolnicze i Leśne, Warszawa.

ŚWITONIAK M., JANKOWSKI M., BEDNAREK R., 2014, Antropogeniczne przekształcenia pokrywy glebowej Brodnickiego Parku Krajobrazowego. Wydawnictwo Naukowe UMK, Toruń.

THE ACT OF 28 SEPTEMBER 1991 ON FORESTS, Journal of Laws 2011, Item 59 as amended.

WIŚNIEWSKI P., 2012, Przeciwerozyjna funkcja lasów glebochronnych na przykładzie obszarów zarządzanych przez RDLP w Toruniu. PhD thesis, Uniwersytet Technologiczno-Przyrodniczy, Bydgoszcz.

WIŚNIEWSKI P., WOJTASIK M., 2012, Glebochronna funkcja lasów a zalesienia porolne na przykładzie Nadleśnictwa Szubin. Polish Journal of Agronomy, 11: 81–88.

WIŚNIEWSKI P., WOJTASIK M., 2014, Zróżnicowanie właściwości gleb uprawnych oraz leśnych na erodowanych stokach. Inżynieria Ekologiczna, 39: 198–208.

WYSOCKI CZ., SIKORSKI P., 2009, Fitosocjologia stosowana w ochronie i kształtowaniu krajobrazu. Wydawnictwo SGGW, Warszawa.

ZAJĄCZKOWSKI J., 2003, Rola zasad hodowli lasu w kształtowaniu trwałej wielofunkcyjności polskich lasów i leśnictwa. Sylwan, 147: 3–9.

Manuscript received 23 January 2015,
revised and accepted 9 April 2015