Impact of a forest regeneration method used after fire on some soil properties

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Introduction

Fire is a natural element that strongly influences plant associations so this agent is of a great importance for silviculture and forest management. In timber woods one of the most important purposes of foresters after fire is to restore forest stands in burnt areas. The methods of forest regeneration used in this exertion can be divided into two general groups: (i) with usage of natural succession and (ii) planting trees. Both main forest regeneration methods influence soil properties that result in e.g. differences in plant or seedling overcrowding. Moreover mentioned two main groups of forest regeneration are usually different as intensity of soil scarification is taking into account, that also effect soil properties.

The main tree species of Polish forests (about 70% of cover) is Scots pine (*Pinus sylvestris* L.). Although the species commonly seeds in burnt areas after forest fires (Obmiński 1970, Hille et al. 2004, Marozas et al. 2007) natural succession was not wide used in restoring such areas in the 20th century in Poland and planting method prevailed. In conformity with 'close to nature' forest management in last decade the natural method of forest regeneration in Polish silviculture has clearly increased. Yet, differences of regeneration method in aspect of effect on soil properties have not been well recognized. The aim of the research was to evaluate the impact of forest regeneration method used after fire on some soil properties in Central Poland. As the subject is connected to forest management the study was analysed in aspect of silviculture.

Methodology

The study was conducted in the Cierpiszewo fire area (52°57'N, 18°27'E; 50 m a.s.l.) in Central Poland (fig. 1), where almost 30 km^2 of pine forest was burnt in 1992. The fire has been one of the biggest of all forest fires in Poland in last hundred years. The mean yearly precipitation in the investigated area is 523 mm and the mean air temperature is 7,9ºC (Wójcik, Marciniak 2006).

We investigated soil properties almost 20 years after fire in 3 study plots of different forest regeneration method used after fire: A. the pine thicket of a natural seeding origin, B. the two generation pine stand: the parent pine stand (burnt by surface fire of low severity only) of loose crown density (ca 30%) with underwood of young (post-fire) pine thicket of a natural seeding origin, C. the pine thicket of a planting origin. In the plot A and B soil was not intensive cultivated after fire, it was only partially surface scarified during removing burnt trees. In the plot C soil was prepared by a plough after fire and before tree planting. All the analyzed plots are characterized by the soil of Brunic Arenosol (IUSS Working Group WRB 2007).

In each investigated plot soil samples were collected for laboratory analysis. In the plot C samples were collected both from rows and interrows of post-ploughing micro-relief. Six samples of each O subhorizons (Oi and Obu – "old" litter, burned during the fire (Gonet

et al. 2007, Gonet 2010)) and the AE horizon were randomly collected in every pine stand. For these horizons the mean values of soil parameters are given in the paper. From each of deeper soil horizons (BwoBs, Bwo) one sample was collected from a soil pit dug in every plot. In soil horizon descriptions of the C plot, where soil was scarified by a plough, "au" index was added to autochthonous and "al" index to allochthonous soil horizons. The other horizon descriptions were given according to WRB (IUSS Working Group WRB 2007).

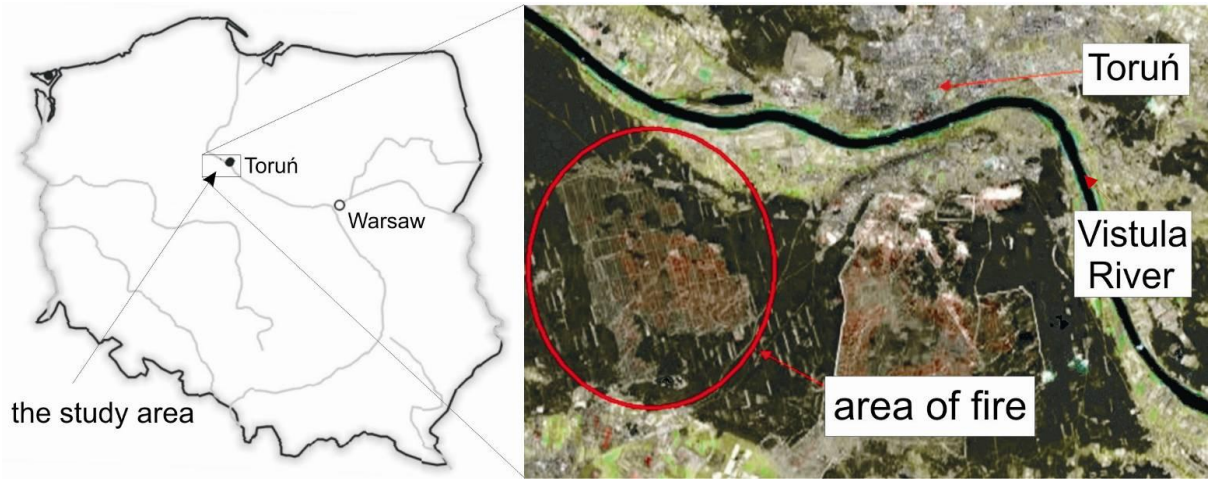

Figure 1. The location of the investigated area

In every collected soil sample the following parameters were determined (Bednarek et al. 2004):
- organic matter (OM) content – by the ignition method (3h in 550ºC),
- organic carbon (OC) content – by sample oxidation in the mixture of $K_2Cr_2O_7$ and H_2SO_4,
- total nitrogen (Nt) content – by the Kjeldahl method.

Results and conclusions

The thickness of the forming after fire Oi subhorizon was significantly higher in both investigated thickets of a natural origin than in both analyzed positions (rows and interrows) in the greenwood of a planting origin (plot C, tab. 1). The main reason for the differences is probably dissimilar density of young pines in the investigated plots that is an important factor shaping organic biomass supply onto soil surface. The density was much more in the plot A (206 pines in 100 m^{-1}) and B (216 · 100 m^{-1}) than in the plot C (75 · 100 m^{-1}, Sewerniak 2010). In the plot C the thickness of the Oi subhorizon was related to the location in a post-ploughing micro-relief. It was much higher in rows than in interrows (tab. 1).

In the investigated thickets of natural origin (plot A and B) the total soil organic matter stock was similar as in interrows in the plot C and significant higher than in rows of the planted thicket (plot A: 9,2 kg · m^{-2}; plot B: 10,1 kg · m^{-2}; plot C: rows – 5,6 kg · m^{-2}, interrows – 9,1 kg · m^{-2}). The differences between plots, concerning the total stocks of OC and Nt were similar to dissimilarities concerning OM stock. As it can be seen from table 1 the differences in total stocks result from altered stocks in surface soil horizons (O and AE) mainly. Particular distinct difference concerned total nitrogen stock in the Oi subhorizon. In the plot C it was clearly lower (rows – 11,4 g · m^{-2}, interrows – 2,77 g · m^{-2}) than in plot A (27,2 g · m^{-2}) and B (22,1 g · m^{-2}). The obtained C:N ratio values

proved distinct higher biological activity in the Oi subhorizon in thickets of natural origin than in the plot C (tab. 1).

Table 1. Properties of the investigated soils

Horizon	Thick-ness [cm]	OM [%]	OC [%]	Nt [%]	C:N	OM stock [kg·m^{-2}]	OC stock [kg·m^{-2}]	Nt stock [g·m^{-2}]
Plot A								
Oi	3,8	64,8	35,1	1,06	33	1,48	0,94	27,2
Obu	2,0	28,7	15,9	0,93	17	1,98	1,09	63,8
AE	3,0	3,1	1,9	0,08	24	0,80	0,55	22,3
AE2	8	2,3	1,2	0,05	24	2,37	1,28	51,6
BwoBs	6	0,8	0,40	0,02	20	0,73	0,36	18,0
Bwo	21	0,6	0,19	0,01	19	1,81	0,57	30,2
Plot B								
Oi	2,7	60,0	31,9	0,93	34	1,45	0,76	22,1
Obu	2,5	11,0	6,2	0,36	17	1,42	0,80	48,0
AE	2,2	3,1	1,7	0,07	24	0,71	0,41	17,7
AE2	8	2,3	1,37	0,05	27	2,22	1,19	48,2
BwoBs	7	1,5	0,69	0,03	23	1,44	0,66	28,8
Bwo	30	0,7	0,22	0,02	11	2,91	0,97	88,2
Plot C – rows								
Oi_{au}	2,1	69,4	37,7	0,91	41	0,85	0,47	11,4
AE_{au}	3,1	3,0	1,4	0,06	23	0,99	0,48	22,2
$ABwoBs_{au}$	13	1,9	0,83	0,04	21	3,20	1,40	67,5
Bwo_{au}	24	0,2	0,16	0,01	16	0,58	0,54	33,8
Plot C- interrows								
Oi_{au}	0,7	57,6	34,7	0,75	46	0,15	0,12	2,77
AE_{al}	5,3	6,0	3,3	0,12	27	3,16	1,75	62,2
$Obu_{al + au}$	3,5	20,2	11,4	0,42	27	3,00	1,68	63,6
AE_{au}	3,9	3,7	2,4	0,09	27	1,24	0,74	29,4
$ABwoBs_{au}$	4	1,8	0,79	0,04	20	0,94	0,41	21,0
Bwo_{au}	24	0,2	0,16	0,01	16	0,58	0,54	33,8

Except differ pine density in the investigated plots an important reason for the obtained differences of soil properties is dissimilar soil scarification intensity after fire. Ploughing usually increases the rate of organic matter mineralization, so intensive soil preparation in the plot C after fire and before planting can in part explain the results.

Fire results in serious losses of soil nutrients (Lewis 1974, Pritchett 1979, Brais et al. 2000). In restoring of fire areas should be used methods that do not increase the losses. In fresh sandy soils content of organic matter is a decisive factor that determines soil fertility and its moisture properties. Our results show that natural seeding should be more often use in forest regeneration in burned areas. In the Cierpiszewo fire area the pine thickets of the natural seeding origin are only about 5% of all greenwoods. The results suggest also that in regeneration of fire areas intensive method of soil preparation (e.g. plouging) is not an advisible method, that it can increase organic matter mineralization. The method of only surface soil scarification in regeneration of fire areas should be rather applied.

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