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ORIGINAL RESEARCH ARTICLE

Biochemical soil activity in *Taxus baccata L.* stands in forest reserves and managed forests

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Abstract. The aim of these studies was to estimate the enzymatic activity and chemical properties of soils of *Taxus baccata L.* stands in selected forest reserves as well as in managed forest stands that do not belong to reserves. Furthermore, I compared the soil fertility of both types of forest stand using a biochemical soil quality indicator. The studies were conducted in the following reserves: 'Bogdanieckie Cisy', 'Cisy Rokickie', 'Cisy Tychowskie', 'Cisy w Czarnem', as well as in managed forest stands with the same soil and habitat type as the above-mentioned reserves.

Analyses showed a lower activity of urease, asparaginase, acid phosphatase and dehydrogenase in soils of the managed forests than in soils of the reserves. The soil nutrient availability given by the total organic carbon, nitrogen, and alkaline cation content as well as soil sorption capacity were significantly lower outside the forest reserves. Chemical and biochemical parameters were used to calculate a biochemical index of soil fertility. The index was higher for soil in forest reserves than for soil in managed forest stands located outside reserves. The result held true regardless of the biochemical parameters used in calculation.

As has been shown in previous studies on protected areas with no cultivation that are largely influenced by natural processes, biochemical indices can be very useful for comparative analyses aiming at estimating soil quality or the reaction of soil to external factors, both natural and anthropogenic.

Key words: enzymatic activity, chemical properties of soils, forest soils, forest reserves

1. Introduction

The microbial mineralisation of the organic matter guarantees the maintenance of the necessary content of nutrients for plant growth; therefore, it is believed that their activity is closely associated with the fertility and productivity of soils (Balicka 1986; Kieliszewska-Rokicka 2001; Zwoliński 2004; Amacher et al. 2007). Thanks to their high surface area to volume ratio that ensures a closer relationship with the environment, soil micro-organisms react faster than higher organisms to changes in the soil conditions caused, for example, by stress factors or agricultural practices used in production forests. The response of micro-organisms is usually preceded by a noticeable change in the physical and chemical properties of soil, hence it can be treated as an early indicator of their improvement or degradation (Caldwell 2005; Chaer et al. 2009; Piotrowska 2011; Błońska et al. 2013).

Species composition of stands is one of the factors determining the amount of nutrients in forest soils. The plant material (litterfall, dead roots, and root exudates) of various tree species that get to the soil is diversified in terms of chemical properties. This has a significant impact on soil quality and the quantitative–qualitative composition of soil micro-organisms as well as on the microbial decomposition of the organic matter. Błońska and Januszek (2010) demonstrated that pine forests have a greater inhibitory effect on the enzymatic activity of soils than oak forests have.

The previous studies of fresh mixed (LMśw) and fresh (Lśw) deciduous forest habitats conducted by Olszowska

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et al. (2007) showed a discrepancy between the description of habitat types contained in the management plans of forest districts and the actual chemical properties and the biochemical activity of soils. This may be due to an incorrect stand description or incorrect forest management, which can lead to the degradation of habitats manifested by both the depletion of plant communities and the deterioration of the properties of soil top layers. The parameters defining soil fertility are a more precise indicator in the typological diagnosis than the floristic and phytosociological relations, as the latter may undergo strong deformations caused by silvicultural operations. This may therefore suggest, as indicated by numerous studies (Leirós et al. 2000; Saviozzi et al. 2001; Russell 2005), that the properties of soils expressed as their chemical composition and biological activity are a reliable indicator of soil fertility.

The literature data show that there are few studies of on the enzymatic activity of soils in nature reserves. Błońska (2011a) established that the activity of dehydrogenases and urease in agricultural soils set aside for afforestation is lower than in the soils in forest reserves. The studies by Lagomarsino et al. (2011) indicated an increase in the microbial activity in forest soils and a decrease in the soils under vineyards and pastures resulting from the use of the available resources and the reduction in the amount of substrate for soil micro-organisms A comprehensive approach to this issue should, first of all, take into account forest soils characterised by an intact system of genetic horizons. In particular, forest reserves can be used in the studies related to the monitoring of changes in the natural environment.

The aim of the research was to determine the enzymatic activity and chemical properties of soils in the selected yew reserves and managed forests outside the reserves as well as to use the biochemical index for the comparison of soil fertility in and outside the reserves.

2. Materials and methods

The study was conducted in four lowland reserves: 'Bogdanieckie Cisy', 'Cisy Rokickie', 'Cisy Tychowskie', 'Cisy w Czarnem' and in the neighbouring production forests located outside the reserves. Forests outside the reserves had the same type of soils and habitats and a similar species composition as in the reserves (Forest Management Plans of Forest Districts: Bogdaniec (2014), Black Człuchowskie (2012), Rokita (2010), Tychowo (2008)).

The yew reserves 'Bogdanieckie Cisy' and 'Cisy Rokickie' lie in Pomerania. The reserve 'Bogdanieckie Cisy' is located in the macroregion of Pojezierze Południowopomorskie (South Pomeranian Lake District) (314.6/7) and in the mezoregion of Równina Gorzowska (Gorzów Plain) (314.61) (Kondracki 2002). The stands of the reserve occur in fresh mixed deciduous (LMśw) and fresh mixed coniferous (BMśw) forests, on Haplic Arenosols developed from loamy sands. The forest stand consists mainly of beech, pine, oak and yew. The reserve 'Cisy Rokickie' is located in the mezoregion of Równina Goleniowska (Goleniów Plain) (313.25), which is part of Pobrzeże Szczecińskie (Szczecin Coastal Zone). The stands in the reserve occur in the fresh mixed coniferous forest (BMśw), on former agricultural, podzolic soil, sand. Pine, beech, birch, oak and yew are the common species in the reserve.

The nature reserve 'Cisy w Czarnem' is located in the macroregion of Pojezierze Południowopomorskie (314.6/7) and in the mezoregion of the Gwda Valley (314.68) (Kondracki 2002). The stands in the reserve grow in the moist mixed deciduous forest (LMw) habitat, on Saprihisti-Gleyic Podzols and in a small area of Haplic Gleysols. The prevailing area of the reserve is covered by beech pine and alder old-growth forests, with occasional spruce and yew.

The reserve 'Cisy Tychowskie' is located in the macroregion of Pobrzeże Południowobałtyckie (South Baltic Coastal Zone) (313) and mezoregion of Równina Białogardzka (Białogard Plain) (313.42) (Kondracki 2002). The stands of the reserve occur in moist mixed (LMw) and fresh mixed (LMśw) deciduous forest habitats, on Podzols and Haplic Gleysols. The stand consists mainly of beech, birch, and alder, with occasional hornbeam, oak, and yew.

Ten sample plots were established in each of the reserves and five plots in each of the stands outside the reserves. In the years 2011–2013, the overall volume samples were taken from each plot (from 10 points) from organic (O) and humus (A) horizons for chemical analyses and measurements of biochemical soils.

The enzyme studies included the measurement of the activity of four enzymes: urease and asparaginase determined by the colorimetric method, expressed in mg $N\text{-}NH_4$ per 10 g of soil, acid phosphatase by the colorimetric method in mg PNP per 10 g of soil and dehydrogenase by the colorimetric method in mg of phenyl formazan (TFF) per 10 g of soil (Russell 1972). Soil chemical analyses made by the generally accepted methods (Ostrowska et al. 1991) included the determination of: soil pH after adding 1M KCl by the potentiometric method, total nitrogen content by the Kjeldahl method, total organic carbon using a Leco SC-132 analyzer, the content of exchangeable base cations after leaching with 1M ammonium acetate by the atomic absorption method, and hydrolytic acidity (H_h) by Kappen's method.

The sum of base cations (*BS*) and the sorption capacity of soils (T_h) was calculated.

The results of chemical and biochemical measurements were used to calculate the value of the biochemical index of forest soil fertility (BW). In order to calculate the BW index values, the method of Myśkówa et al. (1996) was modified by using the formula:

$$BW = M^2 + C^2 + BS^2 + T_h^2$$

where: *M* – enzymatic activity of soils, *C* – organic carbon, *BS* – the sum of base cations, T_h – sorption capacity.

M in the above equation was replaced by the standardised results of the chemical analyses and measurements of the total enzymatic activity of organic and humus horizons (in standard deviation units), taking alternately, one of the tested enzymes: dehydrogenase (*D*), urease (*U*), asparaginase (*A*) and acid phosphatase (*F*).

The multivariate analysis of variance was used for the statistical assessment of the chemical and biological parameters of soils in the reserves and managed forests. To verify the significance of differences in the chemical and biological parameters between organic and humus horizons, a nonparametric Wilcoxon test was used. The relationships between the biological activity and chemical properties of soils and between individual biochemical parameters of soils were determined using the Pearson correlation coefficients, assuming 95% confidence limits ($p < 0.05$) for the verification of the significance level. Statistical calculations were performed using Statistica 10.

3. Results

Soil chemical properties

The mean values of soil chemical parameters, together with the standard error of the mean are presented in Table 1.

Soil pH on all plots, regardless of the location, was strongly acidic, whereas pH KCl in the organic (O) horizon was significantly lower ($p < 0.001$) compared to the humus (A) horizon. In the reserve 'Bogdanieckie Cisy', soil pH in the A horizon was significantly higher ($p < 0.01$) than outside the reserve, whereas soil pH in the O horizon in the reserve 'Cisy w Czarnem' was significantly lower ($p < 0.05$) than in the soils outside the reserve.

On all the plots, regardless of the place of sampling, the contents of *C* and *M*, and the sum of base cations (*BS*), as well as hydrolytic acidity (H_h) and sorption capacity (T_h) were significantly higher ($p < 0.001$) in the O horizon than in the humus horizon of the examined soils. The chemical analysis showed a significant cor-

Table 1. Chemical properties of soil organic and humus horizons (mean±standard error)

Study plots	Soil horizon	pH_{KCl}	N (%)	C (%)	BS	H_h	T_h
Forest reserve 'Bogdanieckie Cisy'	O	3.19±0.06	1.29±0.07	28.05±1.59	7.19±0.44	60.21±4.58	67.40±4,57
	A	3.34±0.05	0.13±0.01	2.95±0.21	1.07±0.16	17.37±1.85	18.44±1.84
Managed forests	O	3.03±0.07	0.90±0.09	20.99±2.10	6.63±0.58	79.55±6.06	86.18±6.04
	A	3.08±0.07	0.10±0.01	1.96±0.28	0.81±0.21	25.97±2.45	26.77±2.44
Forest reserve 'Cisy Rokickie'	O	2.86±0.06	1.07±0.09	28.35±1.59	6.05±0.42	89.39±5.47	95.44±5.53
	A	3.20±0.08	0.20±0.03	4.96±0.38	0.60±0.11	21.02±1.73	21.62±1.79
Managed forests	O	3.00±0.08	0.89±0.12	16.95±2.10	3.89±0.55	61.37±7.23	65.26±7.32
	A	3.16±0.11	0.25±0.04	3.26±0.50	0.61±0.14	12.50±2.28	13.10±2.36
Forest reserve 'Cisy w Czarnem'	O	2.92±0.02	1.62±0.09	32.93±1.77	8.38±0.72	94.10±4.90	102.48±5.27
	A	2.96±0.06	0.96±0.03	17.90±1.09	1.72±0.21	46.34±6.51	48.06±6.67
Managed forests	O	3.01±0.03	1.07±0.12	15.70±2.35	5.06±0.95	35.40±6.49	40.47±6.97
	A	3.11±0.08	0.38±0.04	7.00±1.44	0.77±0.28	19.63±8.61	20.39±8.83
Forest reserve 'Cisy Tychowskie'	O	3.04±0.07	1.23±0.08	26.55±1.52	9.43±0.65	66.37±4.82	75.81±4.80
	A	3.11±0.09	0.46±0.03	6.59±0.64	2.49±0.25	23.90±2.45	26.39±2.49
Managed forests	O	3.11±0.09	0.36±0.10	6.87±2.02	5.96±0.86	25.10±6.38	31.06±6.35
	A	3.40±0.12	0.08±0.04	1.86±0.84	0.80±0.34	8.26±3.25	9.06±3.30

relation between the content of organic carbon and the place of soil sampling; statistically significantly higher values ($p < 0.05$) were recorded in the reserves 'Bogdanieckie Cisy' and 'Cisy Rokickie' than outside them. The content of organic carbon in the soils of the reserves 'Cisy w Czarnem' and 'Cisy Tychowskie' was two-fold higher than outside the reserves, the differences were statistically significant ($p < 0.001$).

There was more nitrogen in the soils in the reserves than outside them, both in O and A horizons. Significant differences in nitrogen content ($p < 0.01$) were found in the reserves 'Bogdanieckie Cisy', 'Cisy w Czarnem' and 'Cisy Tychowskie'.

The soils in the reserves 'Cisy Rokickie', 'Cisy w Czarnem' and 'Cisy Tychowskie' showed a high content of base cations. In both examined horizons, their sum (*BS*) was significantly larger ($p < 0.05$) in the soils in the reserves than outside the reserves.

The soils in the reserve 'Bogdanieckie Cisy' had significantly lower ($p < 0.05$) hydrolytic acidity (H_h) and sorption capacity (T_h) than the soils outside the reserve. In the reserves 'Cisy Rokickie', 'Cisy w Czarnem' and 'Cisy Tychowskie', the hydrolytic acidity and sorption capacity of soils, both in the O and A horizons were significantly higher ($p < 0.05$) than outside the reserves.

Enzymatic activity of soils

The activity of the enzymes was closely related to the content of organic matter, hence it was significantly higher in the O horizon ($p < 0.001$) than in the A horizon in all the examined soils inside and outside the reserves. (Fig. 1–4).

The activity of urease in the O horizon in all the examined yew reserves was higher than that outside the reserves. In the case of the reserves 'Bogdanieckie Cisy', 'Cisy Rokickie' and 'Cisy Tychowskie' these differences were statistically significant, whereas in the case of the 'Cisy w Czarnem' reserve, they were not significant. The activity of urease in the A horizon in the reserves 'Cisy w Czarnem' and 'Cisy Tychowskie' was significantly higher than outside them (Fig. 1).

Similarly, the activity of asparaginase was higher in the O and A horizons of soils in the surveyed reserves than outside them. The observed differences were significant in the reserves 'Bogdanieckie Cisy', 'Cisy w Czarnem' and 'Cisy Tychowskie' (Fig. 2).

The research showed a significantly higher activity of acid phosphatase in the soils in the reserves 'Cisy w Czarnem' and 'Cisy Tychowskie' than outside them. The activity of this enzyme was also significantly higher in the reserve 'Cisy Rokickie' than outside it, but only in the humus horizon (Fig. 3).

As in the case of the above-discussed enzymes, the activity of dehydrogenase in all the studied reserves was higher than outside them. The differences were statistical-

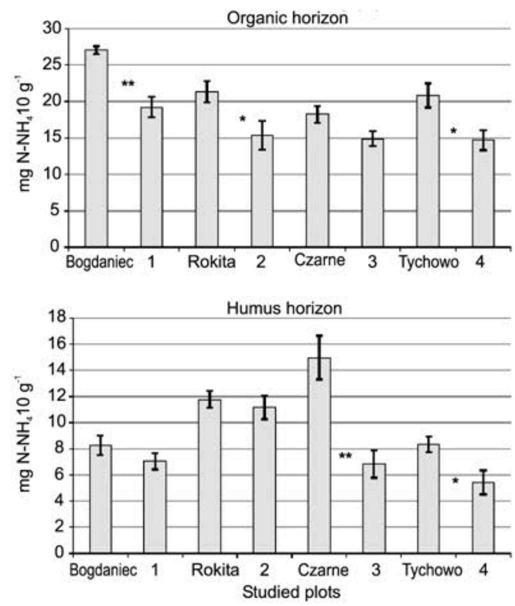

Figure 1. Mean urease activity ± standard error. 1, 2, 3, 4 – managed forests. Designation for significant differences between mean values: * $p < 0.05$, ** $p < 0.01$, ***$p < 0.001$.

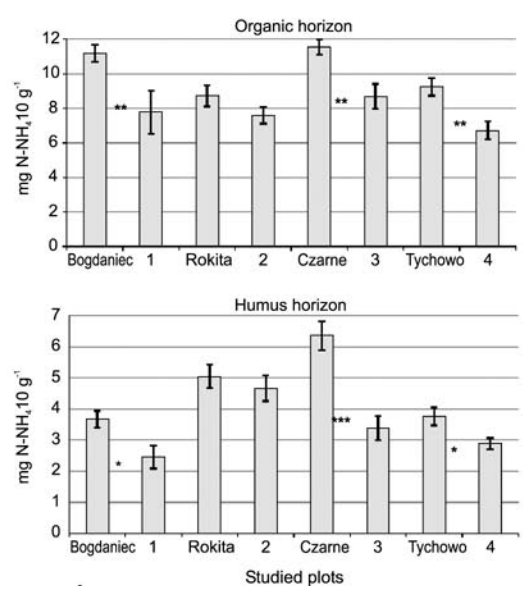

Figure 2. Mean asparaginase activity ± standard error. Designation as in Figure 1.

ly significant only in the O horizon in the reserve 'Bogdanieckie Cisy' and in the A horizon in the reserve 'Cisy w Czarnem', whereas in other cases, the differences were not significant (Fig. 4).

The above-presented biochemical parameters were correlated with the selected chemical parameters. The activity of all the tested enzymes was significantly correlated with the organic carbon content as well as with the sum of cations and the sorption capacity of soils. The activity of urease and acid phosphatase was significantly correlated with the content of nitrogen and hydrolytic acidity. In addition, the activity of urease was significantly correlated with the

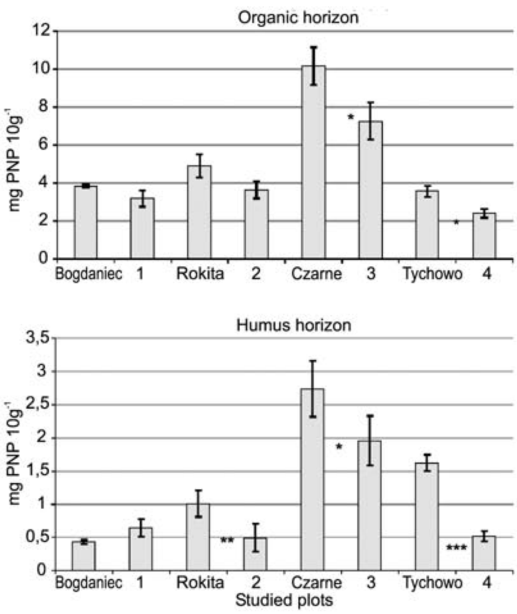

Figure 3. Mean acid phosphatase activity ± standard error. Designation as in Figure 1.

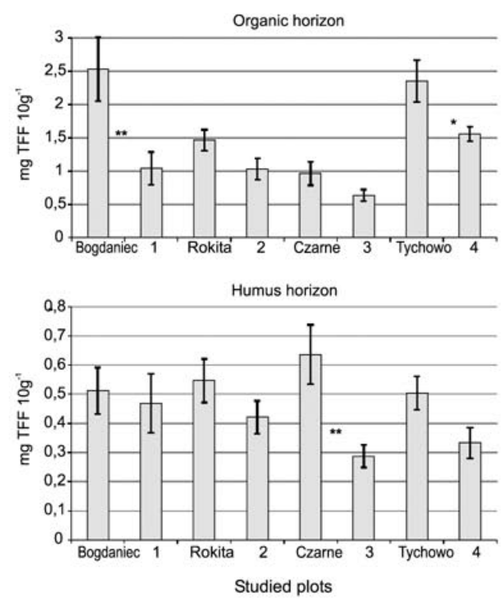

Figure 4. Mean dehydrogenase activity ± standard error. Designation as in Figure 1.

Table 2. Correlations (r_{yx}) between biological (y) and biochemical (x) soil parameters

(x). y	x							
	U	A	D	N(%)	C(%)	BS	H_h	T_h
organic horizon								
U		n	0,3492**	0,4181***	0,3658**	0,2460*	0,2725*	0,2906*
A	N		n	n	n	0,2580*	n	0,2442*
D	0,3492**	n		n	0,4954***	n	n	n
F_{kw}	0,3032*	0,4930***	0,2600*	n	0,5849***	0,2380*	0,5292***	0,5489***
humus horizon								
U		0,6146***	0,2795*	0,4963***	0,6306***	0,2600*	0,3962***	0,3991***
A	0,6146***		n	0,5055***	0,5340***	n	n	0,2365*
D	0,3971***	n		n	n	0,2755*	n	n
F_{kw}	0,2795*	n	0,2494*	0,6667***	0,5871***	0,2904*	0,4447***	0,4478***

U – urease, A –asparaginase, D – dehydrogenases, F_{kw} – acid phosfatase; N(%) – nitrogen, C(%) – organic carbon, *BS* – the sum of basie cations, H_h – hydrolitic acidity, T_h – sorption capacity; designation for significant differences between mean values: *p < 0,05, **p < 0,01, ***p < 0,001, n – not important activity of dehydrogenases, phosphatase and asparaginase, whereas the activity of acid phosphatase correlated with the activity of asparaginase and dehydrogenases (Table 2).

Biochemical soil quality index

The biochemical index of soil fertility (*BW*) was used to assess the fertility of the examined soils within and outside the reserves using the selected chemical parameters in the calculations, showing the amount of nutrients in the soil, as well as the parameters determining soil biological activity (Fig. 5). Regardless of whether in the equation $BW = M^2 + C^2 + BS^2 + T_h^2$, the activity of urease (*U*) or asparaginase (*A*) or acid phosphatase (F) and dehydrogenases (*D*) was used as the biochemical parameter *M*, the *BW* index was significantly higher ($p < 0.001$) for the soils in the reserves 'Rokita', 'Czarne' and 'Tychowo' than outside them. In the case of the reserve 'Bogdanieckie Cisy', the *BW* index was also higher than outside the reserve; however, the difference was not significant.

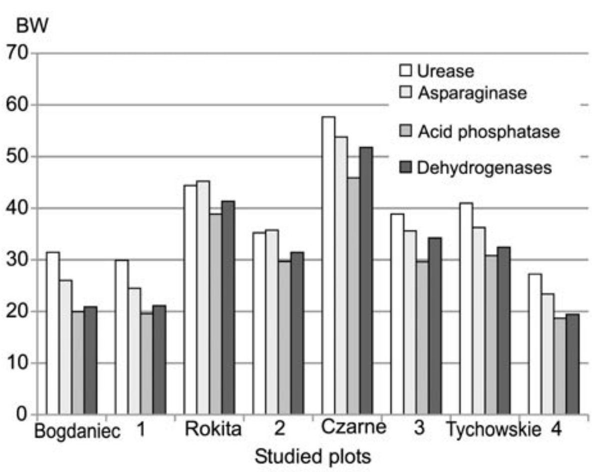

Figure 5. Biological index of soil fertility. Designation as in Figure 1.

4. Summary and conclusions

In the assessment of soil biological activity, the commonly used parameters associated with the primary role of forest soil micro-organisms, that is, mineralisation of the organic matter, were tested. The presented research results show that enzyme activity is closely related to the content of the organic matter, as evidenced in their statistically higher activity in the O horizon than in the humus horizon of the soils in the reserves and in the areas located outside the reserves. Numerous literature data (Landgra et al. 2000; Leirós et al. 2000; Šnajdr et al. 2008; Zwoliński 2008; Olszowska 2010) confirm a close relationship of enzyme activity and growth of micro-organisms with the content of organic carbon as their primary energy substrate.

Large differences in the activity of all the tested enzymes in the soils of each of the reserves can be explained by the impact of a number of environmental factors, for example, moisture, temperature and degree of oxygenation of the soil and the inflow supply of the organic matter (Bauchus et al. 1998; Côte et al. 2000). Many authors (Decker et al., 1999; Smoliński et al. 2008; Piotrowska et al. 2010) also showed a high variation in the enzyme activity of arable and forest soils on a regional, local, topographic and single-tree scale.

The cycling of matter and energy in nature is one of the most important ecological processes, enabling a constant supply of nutrients necessary for plant growth. An important factor in this process is the decomposition of dead organic matter getting into the soil, which is mainly the result of the activity of micro-organisms producing enzymes that are the catalysts in the reaction of mineralisation and synthesis of organic compounds (Burns et al. 1982; Chaer et al. 2008). Soil fertility is associated with the activity of soil enzymes, as indicated in the studies by Zak et al. (1994), Gil-Sotres et al. (2005) and Januszek (2011). The current research has shown a lower activity of urease, asparaginase, acid phosphatase and dehydrogenases in the soils in managed forests than in the reserves. The lower activity of enzymes may indicate a less intensive process of decomposition of the organic matter in the soils of managed forests. Soil processes in the reserves are not affected by silvicultural treatments, which may explain the higher activity of the tested enzymes. In the past, vegetation in these reserves was highly distorted as a result of anthropogenic influences, but over, at least, a few decades, it has been left to natural processes. The lack of silvicultural treatments in the form of felling and tree removal causes a constant supply of litterfall to the soil where it is decomposed by micro-organisms.

The performed comparison of enzymatic activity of the soils in nature reserves and managed forests indicates the impact of management operations activities on soil processes. Dinesh et al. (2004), Nourbakhsh (2007), Lagomarsino et al. (2011) demonstrated that the activity of enzymes may be a sensitive indicator of early changes in the soil conditions caused by silvicultural procedures, including timber harvesting. The positive impact of mid-field woodlots on the activity of urease, phosphatase and protease was confirmed by Bielińska and Węgorek (2005). The earlier studies by Olszowska et al.

(2005, 2009) confirmed that the activity of soil enzymes and the microbial status of soils as well as their chemical properties were conditioned by habitat quality and generally decreased with the decrease of stand quality.

The disturbances in soil microbial activity, manifested by the lower activity of soil enzymes, may affect the chemical properties of soils. This was confirmed by the tests of chemical parameters, of which the results are presented in this paper. The amount of nutrients expressed as the content of organic carbon, nitrogen and base cations in the soils outside the reserves, was significantly lower than in the reserves. The sorption capacity was also lower there. According to Gonet et al. (2009), the physical and chemical properties of soils are determined not only by parent rocks and climatic conditions, but also by the method of land use. Changing the species composition of forest stands is one of the main methods of human intervention in forest ecosystems. Assessing the industrial impact on the chemical modification of soils, Kusza and Strzyszcz (2005) and Kusza (2007) found that forest land, especially in the areas excluded from intensive management, such as nature reserves or national and landscape parks, provide better opportunities to study the naturally preserved soil profiles in these areas.

The physical and chemical properties of soils are strongly linked with and have a significant impact on soil organisms, and thus on the activity of enzymes (Aikio et al., 2000). A number of studies indicate a significant correlation between biological activity and soil fertility (e.g. Zwoliński 2004; Trasar-Cepeda et al. 2008). This is confirmed by the results of this study, indicating a clear dependence of the activity of enzymes on the chemical properties of soils. The above-discussed soil biochemical characteristics were significantly correlated with, at least, several parameters defining soil fertility, such as the content of organic carbon, nitrogen, total base cations, hydrolytic acidity and sorption capacity. The low values of the correlation coefficient, although statistically significant, indicate that biochemical parameters, in addition to the tested soil chemical properties, were influenced by other factors, such as soil grain-size distribution, organic matter quality determined by the species composition of stands and climatic conditions (Bauchus et al., 1998, Côte et al., 2000). All the examined biochemical parameters are related, albeit in different ways, with the process of decomposition of the organic matter that guarantees the maintenance of necessary nutrient supply for plant growth. Significant correlations between the activity of the tested enzymes and parameters of soil fertility indicate that each of these parameters can be used in biochemical studies as an indicator of soil quality. Soil properties are considered to be a reliable indicator of the fertility of habitats characterised, among others, by chemical composition, microbiological status and enzyme activity (Burns 1982; Lasota, 2005; Januszek 2011). The biochemical index of soil fertility (*BW*) was used to assess the quality of agricultural soils where its values showed a significant correlation with maize crop (Myśków *et al*. 1996). In this study, the *BW* index was higher in the reserves, compared to managed forests, regardless of which biochemical parameters were used in the calculations. The previous studies of coniferous lowland and mountain habitats by Olszowska et al. (2005, 2009) showed a significant correlation between the *BW* index, and dendrometric parameters, which indicates the usefulness of this index for the assessment of habitat quality. Zornoza et al. (2007) developed an indicator of soil fertility by using physical, chemical and biochemical parameters correlated with the content of nitrogen and organic carbon. A similar correlation between soil quality and productivity was confirmed in the study by Błońska (2011b) and Błońska and Januszek (013).

The relatively minor use of biochemical tests in the diagnosis of forest soils is due to the lack of standardised analytical methods that might help interpret the results (Sariyildiz et al. 2005). The diversified forest soil profile structure as well as the impact of a number of environmental factors on the activity of soil enzymes make it impossible to establish 'norms' of biochemical parameters for each type of soil or forest habitat, as in the case of chemical parameters (Moffat 2003; Amacher et al. 2007). Biochemical indices can therefore be very useful in the comparative studies to assess the quality of soils or their response to external factors, both natural and anthropogenic. This study conducted in nature protection areas characterised by the ongoing natural processes and lack of management treatments proves this. This speaks for a wider use of biochemical indices in the studies of forest soils, especially when assessing the impact of stress factors (e.g. industrial pollution, fires, and extreme weather events), climate change and silvicultural treatments on forests as well as in predicting their further growth.

The enzyme activity is closely related to the content of organic matter. It is statistically significantly higher in the O than in the A horizon, both in and outside the reserves.

The content of organic carbon, nitrogen and base cations in the soils as well as soil sorption capacity were found to be significantly lower in the managed forests than in the reserves.

An increased activity of urease, asparaginase, acid phosphatase and dehydrogenases in the soils in the reserves than in the soils of managed forests may indicate a positive effect of the departure from forest utilisation in nature reserves.

The significant dependence of the enzyme activity on soil chemical properties supports the possibility of calculating a biochemical index of soil fertility (*BW*) which for the soils in the reserves is higher than for the soils outside the reserves, regardless of whichever biochemical parameters were used in the calculations.

The biochemical index of soil fertility (*BW*) may be useful in comparative studies as well as in the assessment of soil quality or their response to external factors, whether natural or anthropogenic.

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