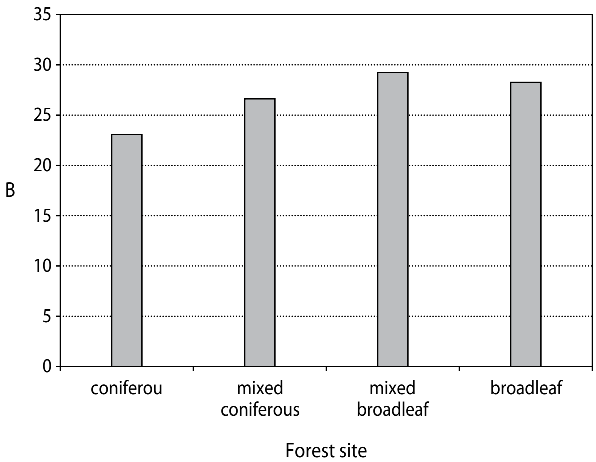


**Fig. 1.** Relationships between the site index of pine stands (B) and forest site type

The site index estimated on the basis of the model of top height growth of oak stand was the lowest in mixed coniferous forest site (20.95). The highest value (24.91) was noted in broadleaf forest site (fig.2).

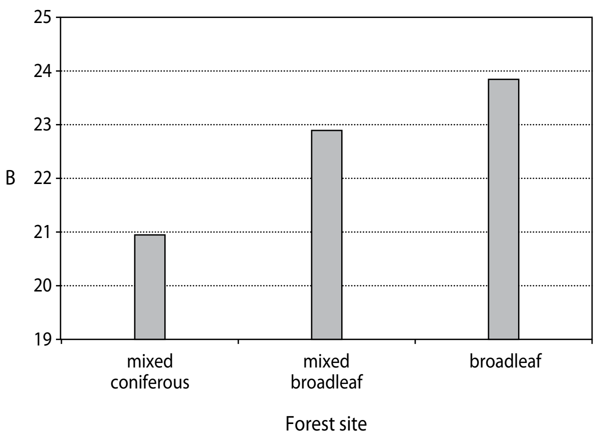


**Fig. 2.** Relationships between the site index of oak stands (B) and forest site type

The site index was correlated with enzyme activity. The site index of pine stand was strongly correlated with dehydrogenase activity in the humus horizon expressed in units of weight (*r* = 0.66) (tab. 5). Similar correlations were obtained between the site index of pine stands and urease and protease activity in the humus horizon calculated over to 1 $dm^3$ of soil (*r* = 0.51, *r* = 0.52) (tab. 5). The site index of oak stand was strongly correlated with urease activity calculated over to 1 $dm^3$ of soil (*r* = 0.95). Soil quality index was correlated with the site index of pine and oak stand (*r* = 0.62, *r* = 0.79) (tab. 5).

**Tab. 5.** Correlations between site indexes and soil quality index and enzymes activity

| Site index | W | ADh | AU | AP |
|---|---|---|---|---|
| Pine | $0.62^{***}$ | $0.66^{***}$ | $0.51^{**}$ | $0.52^{**}$ |
| Oak | $0.79^{*}$ | 0.66 | $0.89^{*}$ | 0.37 |

W – soil quality index, ADh – dehydrogenase activity in humus horizon expressed in units of weight, AU – urease activity in the humus horizon calculated over to 1 $dm^3$ of soil, AP – protease activity in the humus horizon calculated over to 1 $dm^3$ of soil, *** – significant at α = 0.001; ** – significant at α = 0.01; * – significant at α=0.05

## Discussion of results

Dick (1994) believes that soil enzyme activity may be a good indicator of soil quality because determination of the enzymatic activity is relatively simple and quick, and enzymes react quickly to changes in the environment. In addition, the enzymatic activity in soil plays an important role in catalyze reactions necessary for life processes of soil microorganisms, decomposition of organic residue as well as circulation of nutrients in the creation of organic matter and soil structure. Enzymatic processes are closely related to soil quality, they participate in the processing of unavailable forms of nutrients readily assimilated by plants (Sinsabaugh et al. 1994). Single biological and biochemical properties should not be used to assess soil quality because they are subject to seasonal and spatial changes (Nannipieri et al. 1990; Nannipieri 1994). It is, therefore, necessary to create indexes which are a combination of several soil properties, which more fully reflect fertility and quality of soil. The results obtained indicate that physical and chemical properties are less distinguishable in the tested soils in comparison to the activity of enzymes. The soils under coniferous forest and mixed coniferous forest had similar physical and chemical properties, such as texture, pH in $H_2O$ and KCl, and C.N ratio (tab. 1). Urease and dehydrogenase activities significantly differed and separated the soils under coniferous forest and mixed coniferous forest (tab. 2).

Taking into account the opinions of the authors quoted above, in order to build the index of forest soil quality there were used the activities of dehydrogenases and urease in the humus horizon calculated over to 1 $dm^3$ of soil and the degree of base saturation in the transition level to parental material. The formula of this index uses biochemical and chemical properties of soil which were selected using statistical methods. Many researchers limited the number of properties on which they based their rates, treating physical and chemical properties as less important in assessing soil quality (Stefanic et al. 1984; Nortcliff 2002; Gil-Sotres et al. 2005). Gil-Sotres et al. (2005) believe that creating a universal tool to assess soil quality is very difficult because climatic conditions (temperature, precipitation, etc.) are very diverse. In this paper the authors use the activity of two enzymes (dehydrogenase and urease), which are cited in literature as a good tool to assess soil quality Stefanic et al. (1984), Beck (1984), Myśków et al. (1996), Kucharski (1997), Januszek (1999), Koper and Piotrowska (2003), Lasota (2005), Puglisi et al. (2006).

The activity of urease as well as dehydrogenase reacts promptly to changes in the use of soil (Pascual et al. 1999; Saviozzi et al. 2001; Gil-Sotres et al. 2005). Kandeler and Eder (1993) suggest that urease activity could be used as an indicator of changes in soil. Kucharski (1997), Januszek (1999), Gil-Sotres et al. (2005), Puglisi et al. (2006), Zornoza et al. (2007) propose urease activity as one of the components of biological indicators to assess soils. Many authors mention β-glucosidase as a useful parameter for determining soil quality because it negatively reacts to agricultural operations, although organic fertilization increases its activity (Bandick and Dick 1999; Pascual et al. 1999). Eivazi and Tabatabai (1990) reported a positive correlation between β-glucosidase activity and organic carbon content and negative correlation with pH. The close relationship between β-glucosidase activity and soil properties (microbial biomass, organic matter, soil texture) suggest that β-glucosidase activity may provide information about soil quality and it can play an important role in monitoring biological soil quality (Turner et al. 2002). Trasar-Cepeda et al. (2000) concluded that the activity of β-glucosidase in addition to urease activity as well as the activity of phosphomonoesterases and dehydrogenases can be used to assess soil degradation. Rodríguez-Loinez et al. (2007) successfully used β-glucosidase activity to assess the quality of arable and grassland soils. These studies did not confirm the above-described relation. The β-glucosidase activity showed the lowest correlation with physical and chemical properties of the soils observed. This suggests that β-glucosidase activity is not a good indicator to assess forest soils.

Sorption capacities of soils determine storage of nutrients, immobilization of toxic elements responsible for water retention in soil and circulation of trace elements. In our study, one component of the formula for assessing soil quality is the degree of base saturation in the transition level to parental material. The fertility of the parent material should be appreciated because together with soil moisture and climatic conditions it jointly determines soil-forming process, soil fertility and its suitability for silviculture. Particularly, in the case of mountain forest soils, indicators of their potential for production and suitability for forestry and farming. Therefore, the quality index developed includes the degree of soil saturation with alkaline cations in the transition level to parental material. Lasota (2005) believes that deeper soil levels cannot be omitted in the calculation of soil quality index because they often constitute a kind of "reservoir" of nutrients which co-decide about the quality of forest soils.

Quantitative assessment of the quality of forest soils is difficult. Research has been conducted in this area for many years. In agriculture, the role of such index is usually expressed by crop yields. The whole produced biomass is also often used as an indicator. The use of these methods is limited in the case of trees,. In Polish forest practice the tree height relative to the species and age is most often used as an indicator of site quality, assuming productivity due to the quality of habitat. Carmean (1975) believes that the quality of site may be expressed by the height of trees of a certain age. Schoenholtz et al. (2000) believe that the quality of soil is a part of site quality and should be expressed by the growth of trees or biomass produced. The results obtained indicate a direct relationship between the enzymatic activity and productivity of soil, which is related to the quality of the site. The results confirm the usefulness of soil enzymatic activity to assess the quality of soil. The correlation between the site index and soil quality index was found. A similar correlation between the quality of soil and its productivity was described by Skinner et al. (1999).

## Conclusions

– To assess the quality of forest soils dehydrogenase and urease activity and soil base saturation in the transition level to parental material were used.
– The activity of dehydrogenase and urease indicates site current condition along with the changes that occur in soil better than soil physico-chemical properties.
– The activity of β-glucosidase showed the weakest correlation with physico-chemical properties of soils. This suggests that β-glucosidase activity is not a good indicator to assess forest soils.
– The correlation between the site index and soil quality index obtained confirm the usefulness of the enzymatic activity for assessments of soil quality

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