SUMMARY

Ecotones are valuable habitats for biodiversity and protect the interior of forests from the influence of harmful external factors. An ecotone zone between two different types of ecosystems may contain the species composition and structural properties found in adjacent habitats, but may also develop microhabitats present only in ecotone areas. Changes in the abiotic and biotic conditions in the edges compared to the interior habitat are called the edge effect which can modify ecological parameters, including changes: in the composition and structure of plant communities, an increase in biodiversity both in terms of the number of species and the life forms of the species represented, as well as changes in interspecies interactions.

Research has shown a relationship between the state of the vegetation in the ecotone zone and biotic resistance in the deeper areas of a forest. The stable and naturally developed vegetation of the forest edge constitute a specific buffer for the spread of non-forest species deep into the forests. Negative impacts on forest edges may originate from the surroundings or from inadequately performed forest management in the ecotone zone. Protection and monitoring of ecotone zones is recommended because they are considered as to be indicators of any environmental changes. In these zones, changes such as the disappearance of sensitive species and the introduction of species with different habitat requirements occur most rapidly. The presented research is expected to verify the following hypotheses:

I. The forest ecotone has different characteristics compared to the neighboring forest zone depending on the environmental conditions of the surroundings in terms of: α – diversity; β – diversity; wealth of functional diversity; the share of photophilous, xerothermic, eutrophic or oligotrophic species, halophytes; method of seed dispersion; method of reproduction; plant life strategies.

II. The plant species composition of the ecotone is different than that of the deep forest and varies depending on the distance from the forest edge.

III. The richness of the functional diversity of the ecotone zone is higher compared to the inner forest zone.

IV. The ecological aspects (estimated on the basis of the Ellenberg index value) and the functional aspects (estimated on the basis of the functional characteristics of

plants) of forest communities depend on the type of use of the forest surroundings and the distance from the forest edge.

V. The edge effect develops in the ecotones of non-degenerated forests.

VI. Changes along environmental gradients are gradual in natural communities with high functional diversity.

The following objectives were adopted in the study:

- comparison of the differentiation of the edge effect in terms of different neighboring areas;
- comparison of the structure on the edges and inside of the forest;
- filling the gap in the recognition of the edge effect phenomenon in research on the ecotone developing between the forest and other natural habitats.

The implementation of the above research objectives allowed to answer the research problem posed in the title of the work, which is shaping the ecotone zone of forest communities depending on various surroundings types.

The object of research are forest areas located in Poland, in the Silesian Lowland and Upland, Kraków-Częstochowa Upland and in the West Beskid Foothills. Data were collected in the form of transects, began from the forest edge and were directed deep into the forest community. Three types of natural habitats were selected, in which transects were designated:

- forests adjacent to water reservoirs,
- forests adjacent to agricultural areas,
- forests adjacent to post-industrial areas.

Each of the transects was 205 m long and consisted of nine study plots. The study plots were 20 m × 5 m in size and were arranged in 0, 5, 10, 20, 40, 60, 100, 150 and 200 m of each transect. The transects were situated perpendicular to the edge of the forest and began at its border. Data obtained such variables as: diameter at breast height, height, percentage of coverage, number of individuals. Species of the tree, shrub and herbaceous layers were identified. Biodiversity indicators were determined for all research fields in transects: species richness [S], Shannon-Weiner species diversity index [H], evenness index, Simpson's dominance index [D] and β-diversity according to Sørensen. In order to assess habitat conditions, the values of the Ellenberg index were calculated, distinguished life forms according to Raunkiaer, seed dispersion method, type of reproduction and plant life strategies according

to Grime. Species origin and conservation status are also taken into consideration. In addition, parameters describing topographic conditions were obtained: altitude, terrain slope, distance from the forest edge, forest habitat type and the degree of habitat transformation. A functional diversity (FD) analysis was carried out, which determines how the values and range of species characteristics affect the functioning of the ecosystem. The analysis of the relationship between species characteristics, habitat characteristics and species composition was carried out using RLQ analysis. This analysis allows for the examination of relationships between environmental and species trait data and species cover data. Indicator species were identified for particular distances from the forest edge. All of the statistical analyses were performed using the R language and environment.

Verification of the research hypotheses allowed for definition specific conclusions:

- The forest ecotone has different features compared to the forest zone, it is characterized by: higher values of α and β – diversity index and richness of functional diversity indicator in ecotones of non-degenerated forests; higher participation of thermophilic species, preferring higher pH, higher soil trophism, halophytes; higher participation of autochor; plants reproducing by seeds and competitors.
- The plant species composition of the ecotone is different than that of the deep forest and varies depending on the distance from the forest edge.
- The richness of functional plant diversity varies depending on the distance from the forest edge. Habitats located in the vicinity of water reservoirs and agricultural fields show high values of the functional diversity richness index. A high value of functional diversity contributes to the development of the "edge effect" phenomenon and resistance to external factors and maintaining the ability to perform ecosystem functions. For transformed forests, the degree of habitat degeneration is more important than the distance from the forest edge, in such cases there is no edge effect.
- The ecological and functional aspects of forest ecotones depend on the type of the use of the forest surroundings, which in particular affects on: humidity, trophism, soil pH, temperature, sunlight, dispersal method and life strategies of plants.
- Habitats characterized by a high richness of functional diversity, α - diversity and β-diversity prove the presence of the edge effect phenomenon, and the

ecotone zone is characterized by very high biodiversity, which presents a relationship between the distance from the forest edge.

The research confirmed the presence of the edge effect in forests with a low degree of anthropogenization, in forest ecotones adjacent to water reservoirs and in forest ecotones bordering on agricultural fields. Forest ecotones bordering agricultural fields are characterized by lower functional diversity, species richness and β-diversity compared to the forest transition zone. An increase in the values of biodiversity indicators was demonstrated in the transition zone, which indicates the presence of the "edge effect" not until than in the forest transition zone, at a distance from 40 - 60 m from the forest edge. The "transpose" of the edge effect may be related to the presence of intense external factors, the intensity of which has a degrading effect on the forest ecotone zone, preventing the development of a defense response in the form of the "edge effect". The gradual mitigation of the intensity of external factors and the well-preserved condition of the forest provide for development of a spatially transposed "edge effect", protection of the remaining part of the forest, with concurrent degeneration of the ecotone zone. Analysis of the variability of the functional diversity richness index confirm the rule that changes along the environmental gradient are gradual in forest communities, which are similar to natural forests and are not exposed to significant anthropogenic influences.