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Biodiv. Res. Conserv. 3-4: 294-299, 2006

DOI 10.14746/biorc.2006.3-4.21

Distribution of silver-fir (*Abies alba* Mill.) in the Sudeten Mts.

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Abstract: This paper presents the assessments concerning the vertical distribution, exposure, slope inclination and land relief of silver-fir localities. The current distribution of fir trees suggest that in the past, *Abies alba* was widespread in the Sudety Mts. at the altitude range 350-800 m. At altitudes of up to 800 m, the number of localities in each zone is often proportional to the total forest area in the zone. Above 800 m, fir trees are now very rare. The studied species is in general similarly frequent in localities with various exposure and degree of slope. It prefers concave landforms (valleys, concave slopes). It can be concluded that the studied species occurs in a wide range of habitats in the Sudeten Mts. This suggests that its withdrawing from the Sudetes is not of natural origin. Main cause of this process is related rather with strong interference of man in forest stand composition.

Key words: vertical distribution, exposures, slope inclination, land relief, forest decline, ecology

1. Introduction

The forestry and botanical publications of the 1990's concerning the fir (Boratyński 1991; Zientarski *et al*. 1994; Jaworski *et al*. 1995; Małek 1996; Boratyński *et al*. 1998; Barzdajn *et al*. 1999; Barzdajn 2000) showed that the resources of this tree in Sudeten Mts. were vary low and it was in a bad condition witch caused threat to its existence. The dying out and rapid elimination of the fir from forests was also recorded by the author of the present paper, who studied the issue in selected stands between 1995 and 1996 (Boratyński & Filipiak 1997). In this situation it became a priority to develop a comprehensive programme for saving this species in the Sudety area. It was assumed that the starting point for this programme was a comprehensive, quantitative and qualitative assessment of the tree resources. The study carried out between 1998 and 2002 show that, fir trees older than 50 years were recorded in over 2000 localities but the mean number of individuals per locality was only about 15. This means that silver-fir is now very scattered in the Sudeten Mts. In most localities only several or even single specimens were found. Frequently they were remnants of larger local populations. The localities with young fir-trees (≤50 years) constituted only 18% of total localities (Filipiak & Barzdajn 2004).

The distribution of silver-fir in different parts of the Sudeten Mts. is uneven (Fig. 1.) The number of fir trees per unit area was the largest in the Bardzkie Mts., followed by Stołowe Mts. and Bystrzyckie Mts. Fir numbers decrease from the north-west to the south-east (Filipiak & Barzdajn 2004).

It was calculated that the average fir stands in the Sudeten Mts. has a primary crown with a length that is approximately 19% of the total tree height and which is damaged in approximately 36%. Trees which grow in the areas with broken canopy and on hilltops are more vulnerable to the impact of pollution carried by wind and fog. An additional factor (besides environmental pollutions) which contributed to the fir damage was their frequent presence in thinned stands with loose canopy closure. In these places the process of crown reconstruction from a broader to a narrower is observed (Filipiak 2005).

In the recent years the level of industrial pollution in the Sudeten Mts. has been strongly reduced. This particularly concerns sulphur oxides (e.g. Filipiak & Ufnalski 2004). This has contributed to the improvement of the crown health of the studied species, but the process of the crown regeneration is slower than the trunk diameter increment restoration (Filipiak 2005).

The isolation and usually small size of local populations of silver-fir make cross-pollination and genetic

exchange very difficult, which has a negative effect on natural reproduction of this species. The severe damage to the top parts of the crown also has a negative effect on the cone crop of the fir (Filipiak 2002a, 2005). The average growth rate class ('stand quality class') of the fir in the Sudeten Mts. is better than expected but about 0.5 degree lower than in the Carpathians (Filipiak 2005).

and the Stołowe Mts. National Park (Sznajder 2001). Updated information on all localities was stored in an Access Database, and the localities were marked on maps used by foresters, on a scale of 1:2500. Thanks to this, it was possible to complete data on altitude, exposure, etc. for localities that were not directly verified. Each locality is marked with the number of

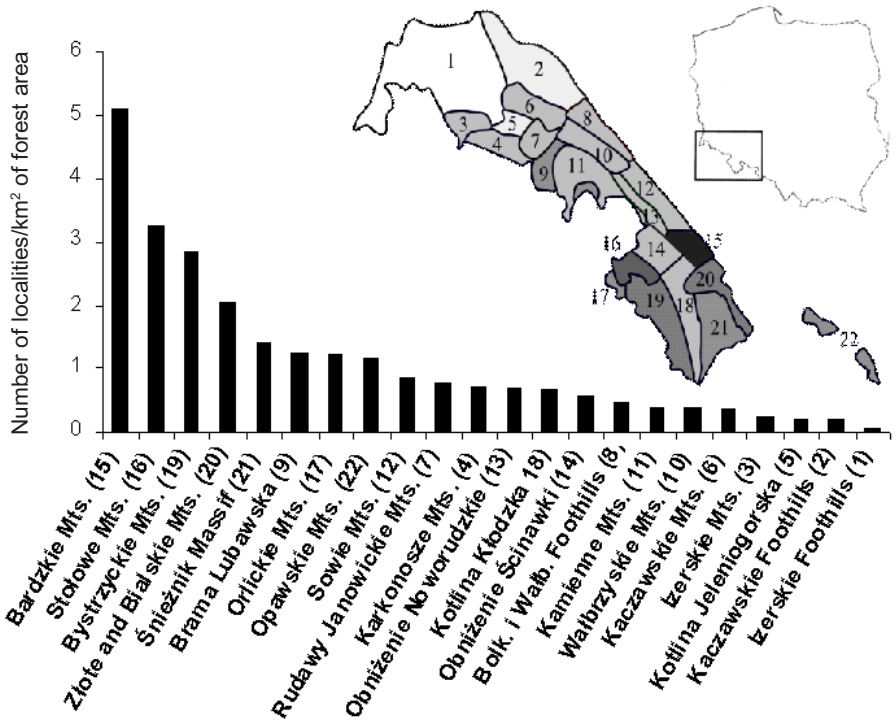

Fig. 1. Number of the Sudetic localities with *Abies alba* by subregion (after Filipiak & Barzdajn 2004)

This paper presents the assessments concerning the vertical distribution, exposure, slope inclination and land relief of fir localities.

2. Material and methods

First, all available data on localization of the studied species were reviewed. The data came from forest assessments ('stand description'), results of own investigations carried out in the years 1995-1996 and inquiry data from forest officers collected under the auspices of the Regional Directorate of State Forests in Wrocław in 1995. Some data (about 5%) came from floristic publications (Boratyński 1991; Kosiński 2001). This information was verified by using of a more detailed questionnaire filled in 1998 by workers employed in forest districts in the Sudeten Mts. and during field research conducted in 1999-2001. Field research was conducted in all forest ranges for which there were reports on silver-fir occurrence, and all the location data were verified with foresters participation. The 854 out of a total of 2575 localities were directly inspected. Additional sources of data were complex inventories made in the Karkonosze National Park (Barzdajn & Raj, *unpub.*) forest subcompartment in which it occurs i.e. the smallest forest units (average surface about 2.5 ha) marked on forest maps and in the field, which differ from the neighbouring plots in stand age, composition, density, volume, spatial structure or some other factor. Occasionally, if the plot was large and fir trees formed several distinct groups within the plot, then each of the groups was marked with an additional digit, for example 345b1, 345b2, etc. Tree age was determined on the basis of forest management reports ('stand description'). Besides, the age of several dozen of trees was verified on the basis of wood samples taken with an increment borer.

3. Results

3.1. Vertical distribution

Considerable differences of vertical distribution of *Abies alba* were observed, depending on the mountain range of the Sudeten Mts. (Figs. 2 and 3). It seems that the decisive factor is the general distribution of forest stands in successive 100-metre altitude zones in the given mountain range. At altitudes of up to 800 m, the number of localities in each zone is often proportional to the total forest area in the zone (Fig. 4).

Above 800 m, fir trees are now very rare. The current distribution and dimensions (Filipiak 2005) of fir trees suggest that in the past *Abies alba* was widespread in the Sudeten Mts. at the altitude range of 350-800 m.

3.2. Exposure

Generally it is believed that *Abies alba* prefers slopes with northern and eastern exposures (Figs. 5 and 6). Also in this respect, large differences were observed depending on the mountain range and a part of the study area. In the Sudeten Mts. such slopes dominate in the Izerskie Mts., Bystrzyckie Mts., Sowie Mts. and Stołowe Mts. By contrast, in the Kaczawskie Mts. and Złote Mts. western slopes prevail. It seems that the type of prevailing exposures in the given mountain range is important. However, the natural distribution has been blurred to a large extent by human interference. In general, silver-fir localities are slightly more frequent on the

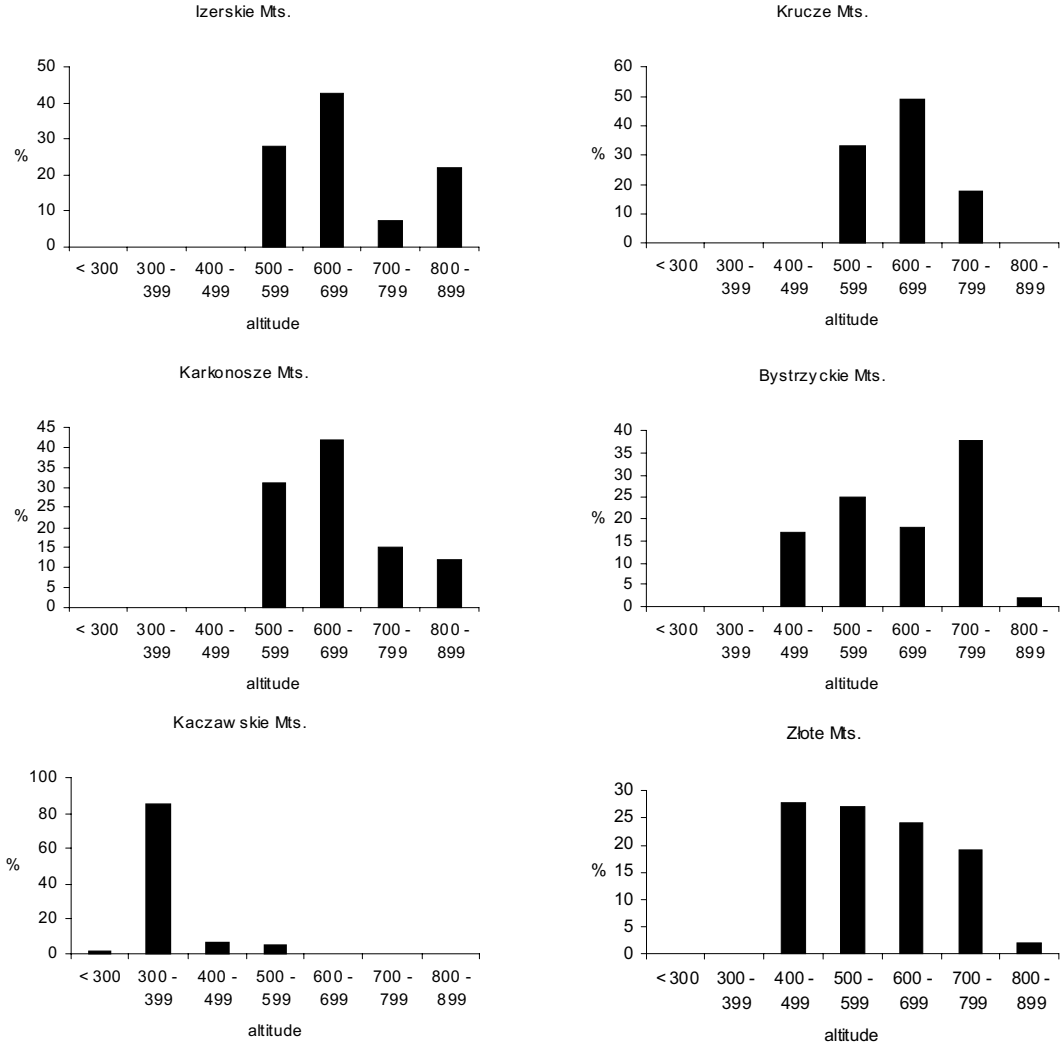

Fig. 2. Distribution of localities of *Abies alba* in 100-metre altitudinal belts in individual subregions in the Sudeten Mts.

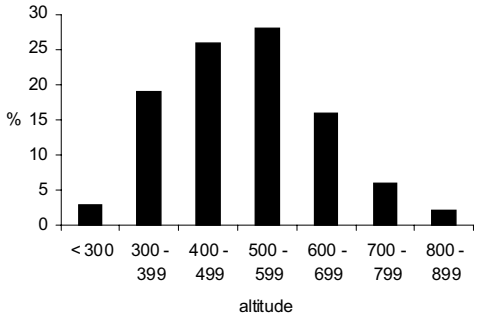

Fig. 3. Distribution of localities of *Abies alba* in 100-metre altitudinal belts in the Sudeten Mts.

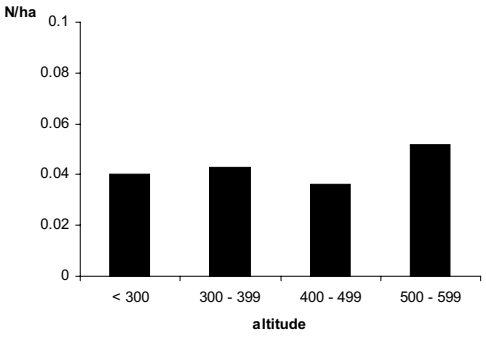

Fig. 4. Number of localities (N) of *Abies alba* per hectare of total forest area in 100-metre altitudinal belts in the Bardzkie Mts. (the range richest in silver fir)

slopes with northern exposures, but differences in the frequency of localities within main exposures are not statistically significant.

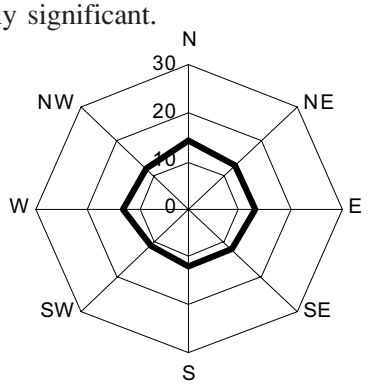

Fig. 5. Distribution of localities of *Abies alba* on slopes with different exposition in the Sudeten Mts.

3.3. Degree of slope inclination

Marked differences were observed, depending on land relief in the given mountain range (Fig. 7). The mean degree of slope in the given range seems to be important. The high frequency of localities with a relatively high degree of slope is probably caused mainly by less intensive forest management, as access to steep slopes is difficult. Nevertheless, it can be concluded that the studied species is in general similarly frequent in localities with various exposure and degree of slope.

3.4. Land relief

Abies alba prefers concave landforms, such as deep valleys of rivers and streams (Fig. 8). Such habitats provide silver-fir with higher humidity and in the past were

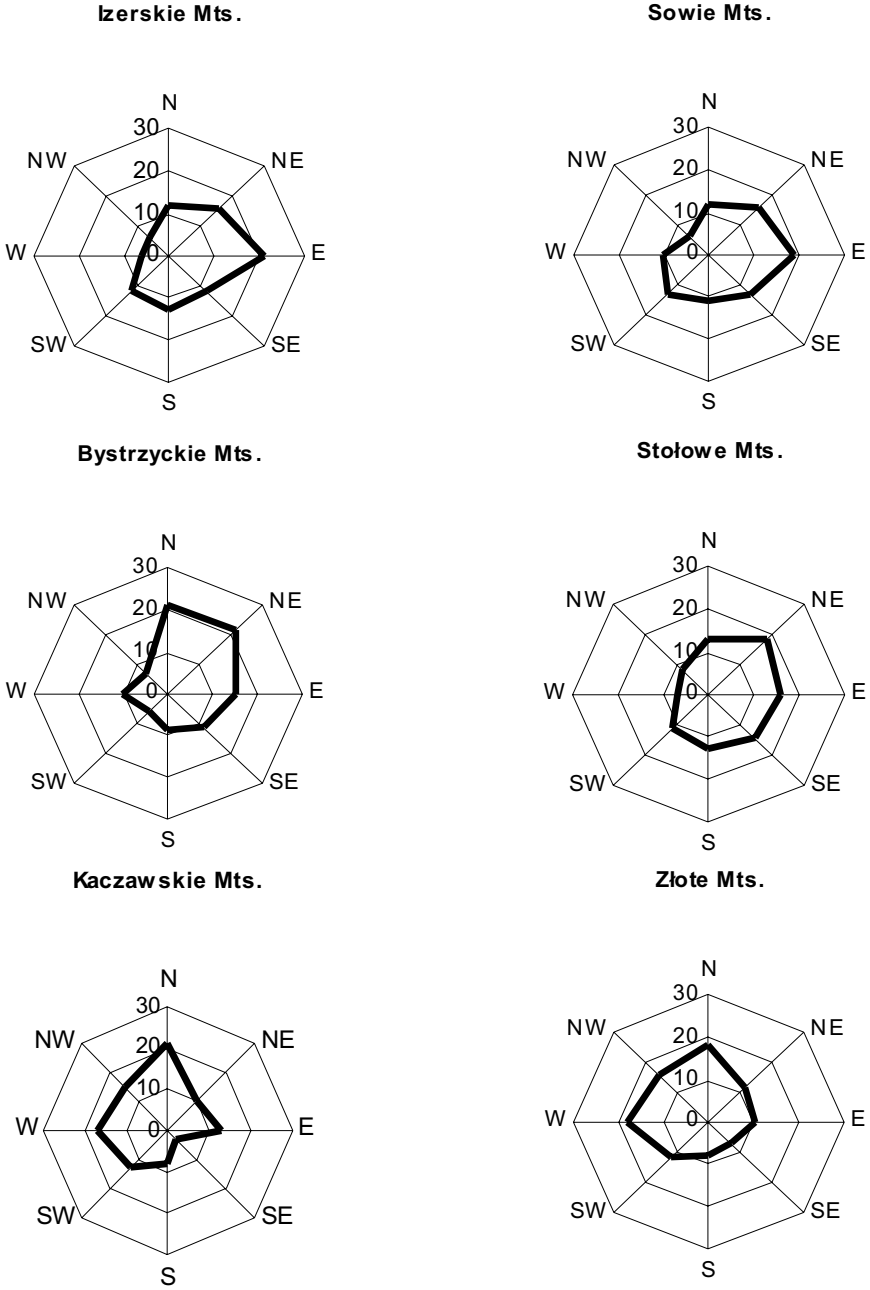

Fig. 6. Distribution of localities of *Abies alba* on slopes with different exposition in individual subregions in the Sudeten Mts.

usually not subjected to the intensive forest management that favours the fast-growing spruce. Over 50% of local populations of silver-fir were found in concave landforms (valleys, concave slopes), although floristic research conducted in different parts of the Sudeten Mts. (Boratyński 1991; Kosiński 2001) suggested that the frequency of such forms is markedly lower than 50%.

4. Discussion

From Middle Ages up till now, silver-fir have reduced participation in forest stands in the Sudeten Mts. at least in 95% (e.g. Filipiak & Barzdajn 2004). In spite of this, it occurs in the majority of forest sites (often with the same frequency). This suggests that its withdrawing from Sudeten Mts. is not of natural origin (e.g. climatic changes). Main cause of this process is related rather to strong interference of man on forest stand composition. This interference was direct in the 19th century and the early 20th century, as a result of intensive forest management which favoured spruce monocultures (e.g. Zientarski *et al.* 1994; Boratyński & Filipiak 1997; Filipiak 2002b). Currently, one of the main reasons of silver-fir decline in the Polish part of the Sudeten Mts. is the small total number of fir trees in that area (0.05% of total forest area) and the small mean size of local fir populations. When small number of fir trees grow in a forest stand, their needs are usually not taken

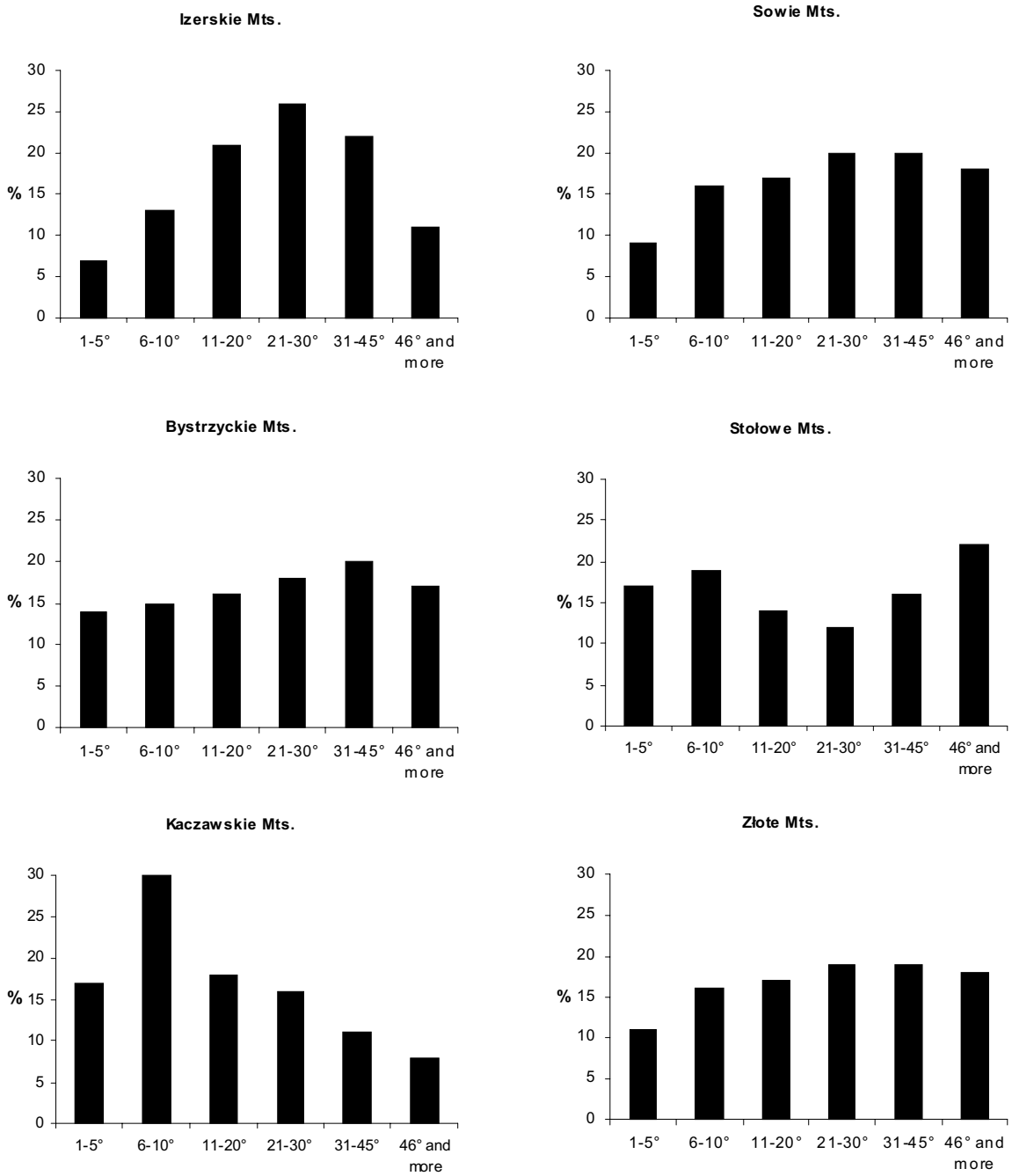

Fig. 7. Distribution of localities of *Abies alba* on slopes with different inclination in individual subregions in the Sudeten Mts.

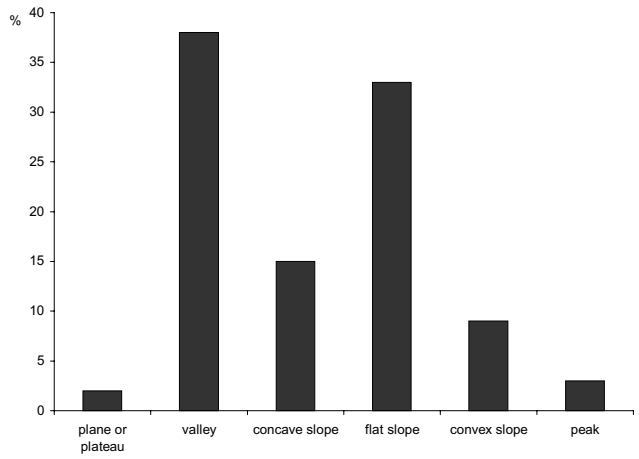

Fig. 8. Distribution of localities of *Abies alba* in different relief forms in the Sudeten Mts.

into account by foresters. Especially, the period of forest regeneration, favourable for renewing of silver-fir should by markedly longer than in the case of spruce and beech (the commonest trees in Sudeten Mts.). Fir trees are also negatively affected by sudden thinning of forest stands. Individuals of this species often suffer from damage to the tree crown due to sudden interruption of forest canopy. Such fir trees were usually felled because they were supposed to die soon due to the damage. However, this supposition proved to be false, because – in contrast to spruce – fir trees can live very long after such damage and in favourable conditions they can effectively regenerate their photosynthetic apparatus.

Acknowledgments. This study was partially supported by the State Committee of Scientific Research, projects No 6 P04G 049 15 and 3P06L 03924.

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