THREATS OF ALDER SWAMP FORESTS IN A CHANGING ENVIRONMENT

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Abstract: Paper concerns a study with changes of vegetation and habitats of alder swamp forest in the Białowieża National Park. The spontaneous succession of natural swamp forests were presented in context of menace environment changes. Remembering that surveys of vegetation are a reliable tool for monitoring temporal variations of the forest environment, those below methods were used in investigation.

Spontaneous vegetation dynamics of swamp forest communities were studied by re-sampling of relevés recorded in the 1960s. Vegetation sampling was carried out according to Braun-Blanquet`s phytosociological method. Changes in species composition and habitat conditions were evaluated in terms of average species ecological indicator values, share of diagnostic species and ordination method. Dynamics of ground flora vegetation according to habitat gradient was expressed by using the Detrended Correspondence Analysis method. Ground water table was monitored from 1985 in the alder swamp forest site. The results of floristic changes and ground water table were referred to measured environmental variables including climatic conditions (temperature and precipitation). The climatic parameters have carried out from 1950 by Institute of Meteorology and Water Management in meteorological station situated on Białowieża glade.

Species composition changed considerably between today and reference studies. According to average ecological indicator values habitat conditions became drier and richer in nutrients. The obtained results indicate changes in water and fertility conditions of forest wetlands, although those changes were not occurred in every samples in the same level. The effect of these changes are a decreasing number and abundance of oligotrophic and swamp species

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as well as an increasing number and abundance of eutrophic species. Observed vegetation and ground water table changes could be caused by the rise of air temperature, especially in winter season.

INTRODUCTION

Within forest ecology, the issue of vegetation dynamics on swamp habitats is a relatively poorly-known one. As forest wetlands represent a management problem for foresters, interest in them has tended to focus on a raising of productivity through the application of drainage, and has hence avoided any consideration of their natural importance. Only more recently has the literature come to feature more and more descriptions of vegetation and stand dynamics in hydrogenic habitats (WILD *et al*., 2004); most notably those of the Białowieża Primeval Forest area (SOKOŁOWSKI 1991, 1999, BERNADZKI *et al*., 1998, BRZEZIECKI AND ŻYBURA 1998), which provides a refuge for natural marshy forest communities of a kind met only rarely in other parts of Europe.

Observation of the succession processes ongoing in vegetation offer a tried and tested instrument by which to diagnose and monitor the changes taking place in the forest environment, as numerous publications make clear (NIEPPOLA 1992, THIMONIER *et al.,* 1994, CZEREPKO 2004). Familiarity with the trends to the changes in hydrogenic habitats (and the rates thereof) may allow for a more precise and rational determination of methods by which to protect habitats, as well as offering conditioning when it comes to the devising of principles by which marshland habitats can be reinstated. The issue of the restoration to a more natural state of hydrogenic habitats is a relatively new one, though workers in Western European and Scandinavian countries plus Canada have already devised methods by which to regenerate peatlands (LODE 1999, PFADENHAUER AND GROOTJANS 1999). The effects they may bring are only likely to become more visible after several more decades.

The present work is concerned with some of the studies supported by a Committee for Scientific Research and The National Fund for Environmental Protection and Water Management grant*, constituting a preliminary reconnaissance of the issue of vegetation dynamics and natural-habitat conditions in forest wetlands within the Białowieża forest. The aim has been to determine the directions and nature of the changes ongoing in the alder swamp forest.

MATERIALS AND METHODS

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The changes in the vegetation of alder swamp forest habitat were determined by way of the repeated (2003 - 2004) generation of 20 vegetation samples (relevés) on permanent plots first established in the 1960s (SOKOŁOWSKI 1993 – 17 relevés) and 1981 (unpublished – 3 relevés: 7808, 7811, 7016). The analysis was concerned black-currant alder *Ribeso nigri-Alnetum* SOLIŃSKA-GÓRNICKA 1975 (1987) community - all located within the Białowieża National Park (Fig. 1). The sample plots have area from $75m^2$ to $400m^2$. The depth of fen on relevés oscillate between 0.05m and 1.94m, with the mean 55cm. The vegetation data were compared in respect of sum species cover coefficient (SCC) of same systematic group (BRAUN-BLANQUET 1964). The classification of species into the different systematic groups followed MATUSZKIEWICZ (2001). The detailed analysis of SCC cover the following systematic units: class *Querco-Fagetea* BR. BL. et VLIEG. 1937, represents mezo- and eutrophic broadleaved forest on mineral soils, class *Alnetea glutinosae* BR. BL. et R. TX. 1943 where are alder swamp forests, class of conifer forests *Vaccinio-Piceetea* BR. BL. et VLIEG. 1939 and alliance of riparian forest *Alno-Ulmion* BR. BL. et R.TX. 1943.

Data from the relevés were subjected to analysis on the basis of ecological indicators values after ZARZYCKI *et al*. (2002). The ecological values derived for the herb layer vegetation offered the basis for the calculation of an average indicator value for the soil moisture and fertility in relation to the year of observation.

A model of vegetation dynamic was generated using the Detrended Correspondence Analysis (DCA) method (HILL AND GAUCH 1980). This algorithm included the main habitat gradients (of soil humidity and fertility) as indicated by the species ecological indicators. The generated ordination diagrams allowed for a determination of the overall rate and directions to habitat changes, in terms of the presence and cover of herb species noted in the vegetation samples.

This article presents the results of measurements of ground water table, which is in ash-alder swamp forest habitat (*Fraxino-Alnetum* W. MAT. 1952). The work also made use of meteorological data from the Białowieża station of the Institute of Meteorology and Water Management.

The mean values generated were then subject to further statistical analysis whereby the significance of the differences ($p < 0.05$) between the periods of research were tested using a Wilcoxon signed-rank test. The DCA algorithm was obtained using the *CANOCO* program (TER BRAAK AND SMILAUER 2002) and the rest statistical analysis using *STATISTICA* package (StatSoft, Inc. 1997).

RESULTS

The number of characteristic species for riparian forests (*Alno-Ulmion) and* broadleaved forest (*Querco-Fagetea)* increased, while *Alnetea glutinosae* and *Vaccinio-Piceetea* species decreased in comparative period of investigation (Tab. 1). The maximum species of the floristically richness survey is higher (30 taxa) in last time than in 1960s and 1981. The bigger changes were occurred in covering of systematic group of species. The *Vaccinio-Piceetea* abundance decreased and *Alno-Ulmion* increased two-times (Tab. 1). The swamp species from *Alnetea* *glutinosae* class decreased but from *Querco-Fagetea* increased its cover by hardly 1/3.

During almost 40 years of spontaneous vegetation development on the swamp forest habitat took place decay and decline abundance of hydrophytes, e.g. *Hottonia palustris, Callitriche cophocarpa* and *Lemna minor*.

The changes of same average properties of alder swamp phytocoenosis in two period of studies are shown in Tab. 2. The cover of second stand canopy, shrub and forest-floor are increased significantly. The average species number decreased significantly (hardly 10 species) in the years 1960 – 2004. The mean value of soil moisture indicator decreased slightly, but significantly. Whereas the nitrogen indicator value are stable.

The DCA model of differences in the vegetation for the phytocoenosis of *Ribeso nigri-Alnetum* suggested that same of the relevés (e.g. 2651,2246,7811,2291) had responded to lower soil humidity and an attendant increase in its fertility (Fig. 2). Plots 2849, 2881, 7808, 2317 seems to have reacted rather differently to the others. 2847, 2651, 2246, 2291 and 2849 plot shows the greatest gradient to changes in floristic composition and cover between the compared relevés – attested to by the greatest separating distance. The smallest changes are occurred in relevés: 2188, 2243 and 2317. The biggest influence to the floristic changes are caused by soil moisture gradient, what is expressed by the longer arrow on the diagram (Fig. 2).

Results of measurements of the water table in the ash-alder forest site show decreases in both the average annual depth and maximum/minimum levels (Fig. 3). The mean depth of the water table was higher by almost 30 cm over 18 years. What is very important for swamp vegetation is the maximum level, and most especially the presence of standing water above ground, which was only in fact present during the earlier period of observations. The last time standing water was noted in 1991.

The total average precipitation in the 1950-2003 period was 626 mm (Fig. 4). In line with the precipitation figures, it was possible to point to three periods with different characteristics. Between 1950 and 1966 the mean annual figure was 573 mm, with only 5 yearly precipitation totals being higher than the long-term average. For the purposes of the present investigation, a very important time came in the second period, 1967-1981 (when for up to 12 years, the precipitation was higher than the average for the whole period, while the mean annual precipitation was of 734 mm). The third and last period started in 1982, with the mean annual precipitation again down – to 593 mm, with only 7 years again having figures above the long-term average. This period experienced as many as 9 dry years with precipitation below 90% of the average, as well as one very dry year with precipitation less than 75% of the long-term mean.

Over the period 1950 – 2003 as a whole, the mean air temperature noted at Białowieża rose by 0.9^{o}C (Fig. 5). In recent years, the rise was mainly related to the winter period, such that the cold half-year (November-April) was as much as

1.5^{o}C warmer on average (Fig. 6). As many as 12 of the most recent 16 years had winter half-years with an average temperature above 0 ^{o}C, the record-holder being 1990 – in which the mean was as high as 3.4 ^{o}C.

DISCUSSION AND CONCLUSIONS

Over almost 40 years of studies of the black-currant alder communities in the Białowieża forest have been shown to pass through significant changes as regards to their floristic composition structure. Vegetation dynamic have mostly been modified by changes in water conditions, as attested to by an increase in indicators of soil humidity in swamp habitats studied. The variant of alder forest has witnessed a limited, if significant, decline in the humidity of soil, being indicated through the disappearance of such hydrophytes as: *Hottonia palustris, Callitriche cophocarpa* and *Lemna minor* (the development of all of which requires standing stagnant water above the ground over much of the growing season – i.e. conditions that should in essence be regarded as typical of natural marshy forest) (MATUSZKIEWICZ 2001). Also the increasing of herb layer vegetation is caused by lack of surface water in alder forest community. The dryer soil conditions in last time are caused by increase of species normally occurred on mineral soils of deciduous forest of riparian and wet habitats.

The greatest influence on the lowering of the water table and attendant decline in the humidity of marshland-habitat soils was constituted by the low levels of precipitation in the later research period, as well as a rise in air temperature enhancing evapotranspiration. A factor of particular significance where soil-humidity conditions in the growing season are concerned is the persistence of snow cover, itself conditioned by persistently low temperatures through the winter. Temperatures rising above zero in the course of the winter permit precipitation to fall as rain, while encouraging the earlier melting of snow. However, it is only the one-off melting of a thick layer of accumulated winter snow – at the end of March and beginning of April – that can make up for a lack of water in the soil through a genuine raising of the water table and ultimately the presence of standing water in alder swamp forest. Today's several episodes of snowmelt in the course of the winter lead to "premature" runoff, and hence to a limitation on the amount of water ultimately available to plants once the growing season commences.

As the desiccation of habitats reflecting more limited precipitation and higher temperatures proceeds, and as the water table experiences an attendant lowering (PIERZGALSKI *et al*., 2002), the result is an increase in the fertility of hydrogenic habitats that reflects the accelerated decomposition of organic matter (SOKOŁOWSKI 1999, CHOJNACKI 2003). Nevertheless, the raising of the level of plant-available nutrient resources in the soil is not yet progressing as fast as the change affecting water relations, perhaps suggesting that the oxidation of the peat is only just now getting underway. It should also be noted that the eutrophication of marshland habitats does not solely reflect the mineralisation of peat, being also stimulated by the atmospheric deposition of nutrients, notably those derived from NO_x (SOKOŁOWSKI 1991).

The results of the DCA analysis of vegetation dynamic confirm that not all plots show the same directions or intensity of change in their floristic composition. This finding serves to justify a continuation of research, and even a further increase in the number of samples, in order that results might be considered more representative and less subject to random factors.

To sum up, the following changes in phytocoenosis may be said to have taken place between the periods compared:

- on the basis of the ecological indicator value site had a lower soil moisture than previously,
- the drier conditions caused species increase of deciduous forest of wet and riparian habitats,
- changes in the water and fertility conditions of alder swamp forest took place, albeit not to the same degree in every relevés, the observed differences as regards vegetation and the water table could be associated with higher air temperatures, especially in winter, on account of the unique nature of natural marshland habitats and their major significance for the retention of both biological diversity and water retention, it would be wise to continue observations of both the development of vegetation and changes in the habitat. The tracing of these phenomena as they take place in conditions of very limited direct human interference may provide very critical input when it comes to that aspect of developed silviculture principles that is concerned with the protection of Poland's hydrogenic habitats.

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Table 1. Changes of share systematic group of species in association *Ribeso nigri-Alnetum*.

Study years	**1960-1966,1981**	**2003-2004**
Systematic group	Number of species	
Alnetea glutinosae	11	11
Vaccinio-Piceetea	11	11
Alno-Ulmion	6	9
Querco-Fagetea	10	16
Rest trees and shrubs	10	11
Accompanying forest floor species	150	110
Total	198	168
	Sum of cover coefficients	
Alnetea glutinosae	841	617
Vaccinio-Piceetea	707	385
Alno-Ulmion	60	140
Querco-Fagetea	370	548

Table 2. Changes of same average properties of Ribeso nigri-Alnetum association. SD – standard deviation.

Study years	1960-1966,1981		2003-2004		Columns difference (4 – 2)
Number of relevés	20		20		
Features	mean	SD	mean	SD	
1	2	3	4	5	6
Mean cover of tree layer a	70.3	2.3	66.8	2.7	-3.5
Mean cover of tree layer a1	61.7	4.0	58.0	4.6	-3.7
Mean cover of tree layer a2	9.8	2.8	17.8	3.9	8.0**
Mean cover of shrub layer b	1.9	0.2	12.8	3.2	10.9**
Mean cover of herb layer c	40.2	4.5	62.0	3.5	21.8**
Mean cover of moss layer d	17.0	4.2	17.7	3.9	0.7
Mean number of species	62.9	2.2	53.5	1.6	-9.4**
Soil moisture indicator value (W)	4.5	0.0	4.4	0.0	-0.1**
Soil fertility indicator value (Tr)	3.4	0.0	3.4	0.0	0.0

** significant difference with p<0.05 refer to Wilcoxon signed-rank test

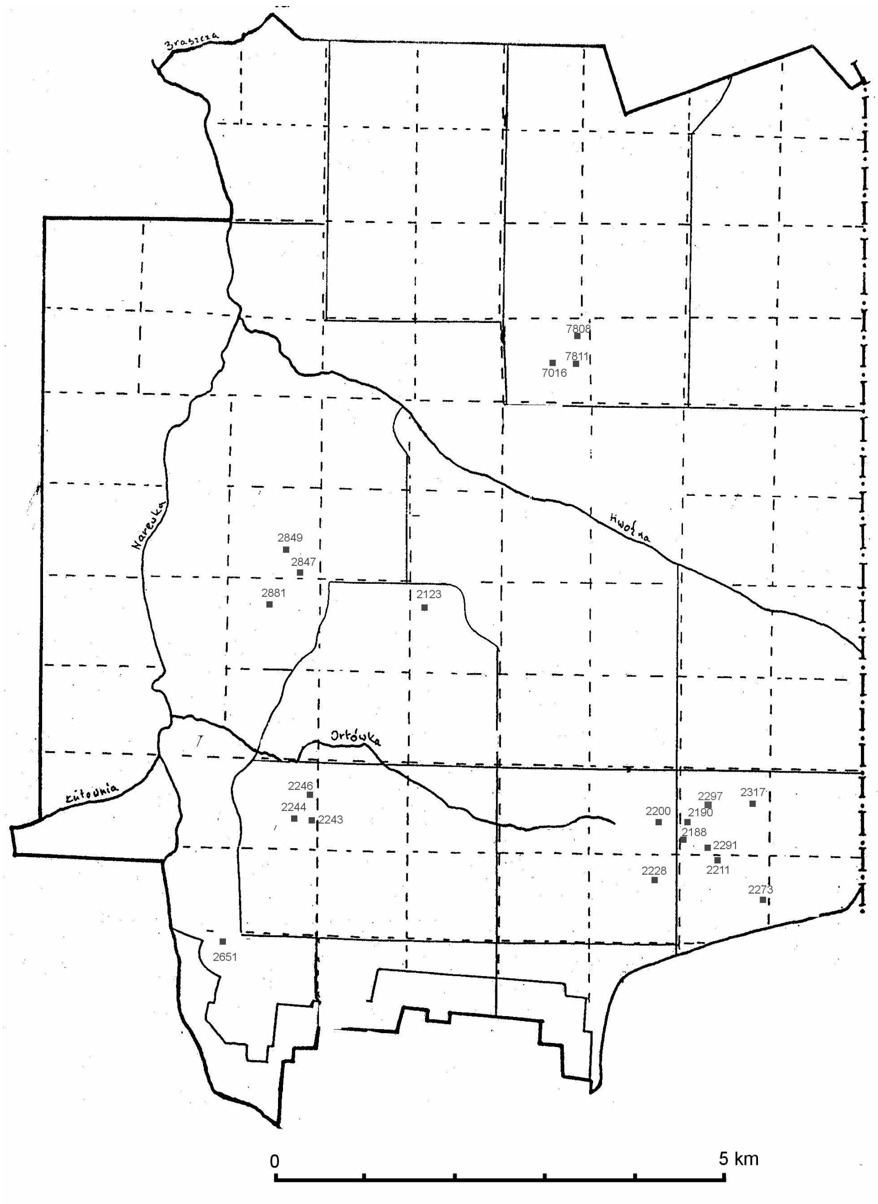

Fig. 1. Distribution of relevés in the Białowieża National Park.

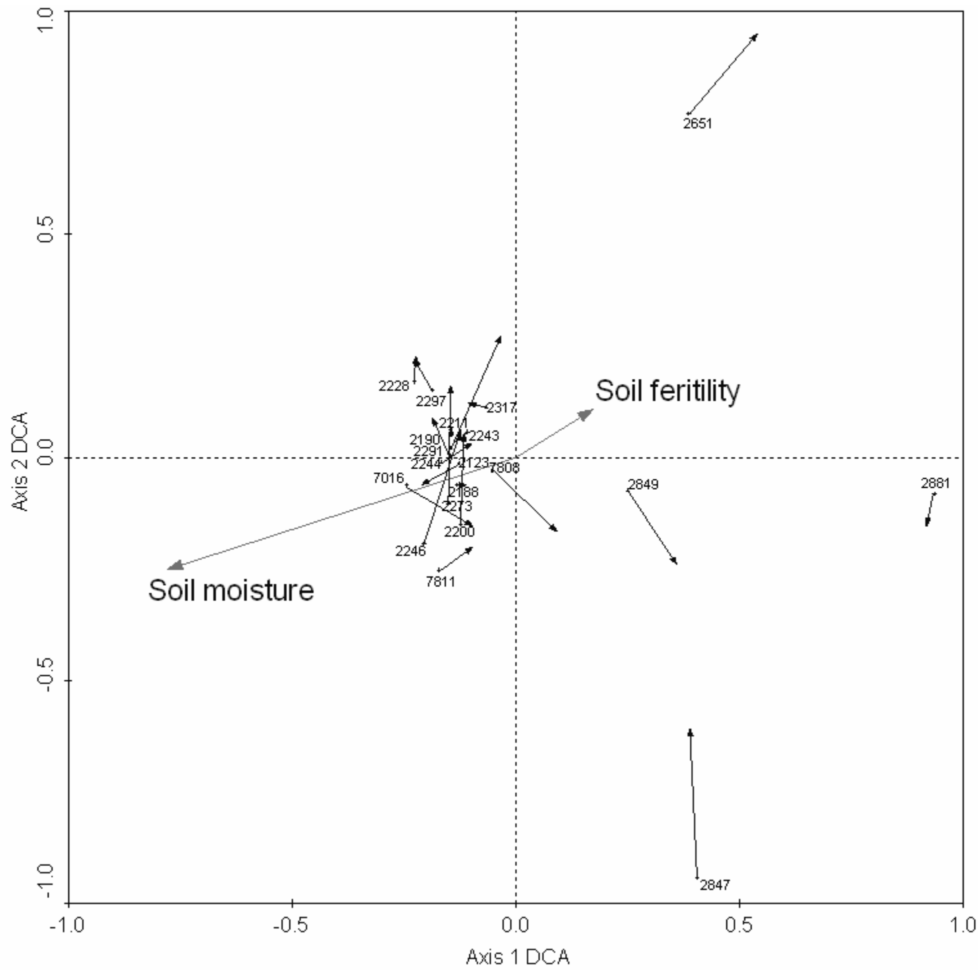

Fig. 2. DCA ordination diagram of relevés in *Ribeso nigri – Alnetum* association according to main habitat gradiends. The changes of composition of herb layer vegetation betwen 1960-2004 are siggned by arrow, with the old relevé at the bottom (number) and the new relevé at the top. The trends and power of habitat gradients are expresed by gray arrows.

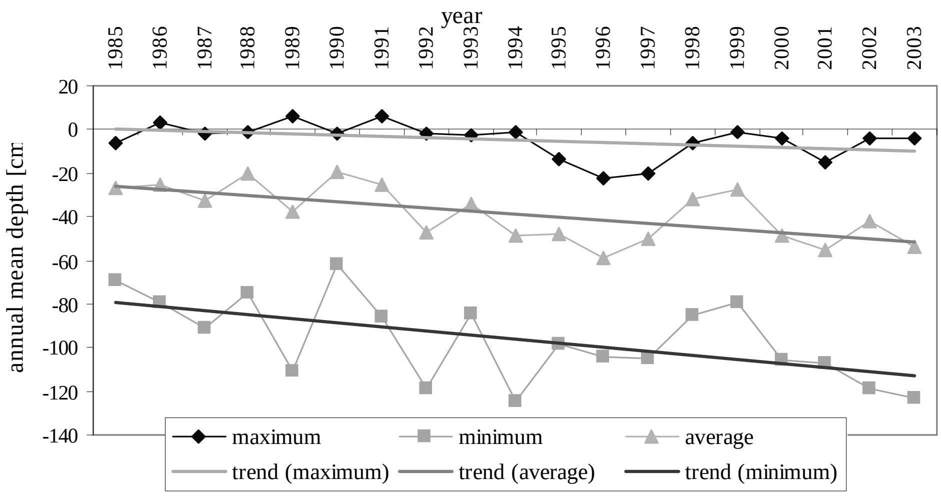

Fig. 3. Ground water table changes in ash-alder swamp forest**.**

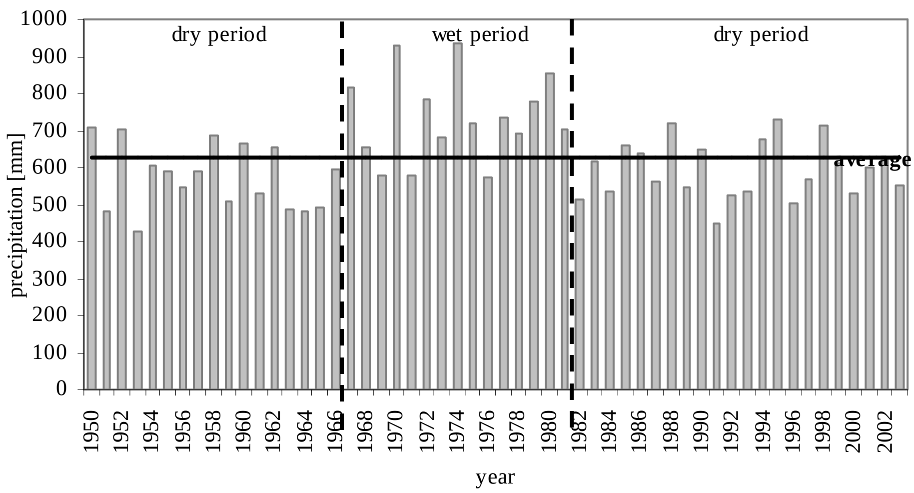

Fig. 4. Precipitation measured in Białowieża meteorological station in the period 1950-2003**.**

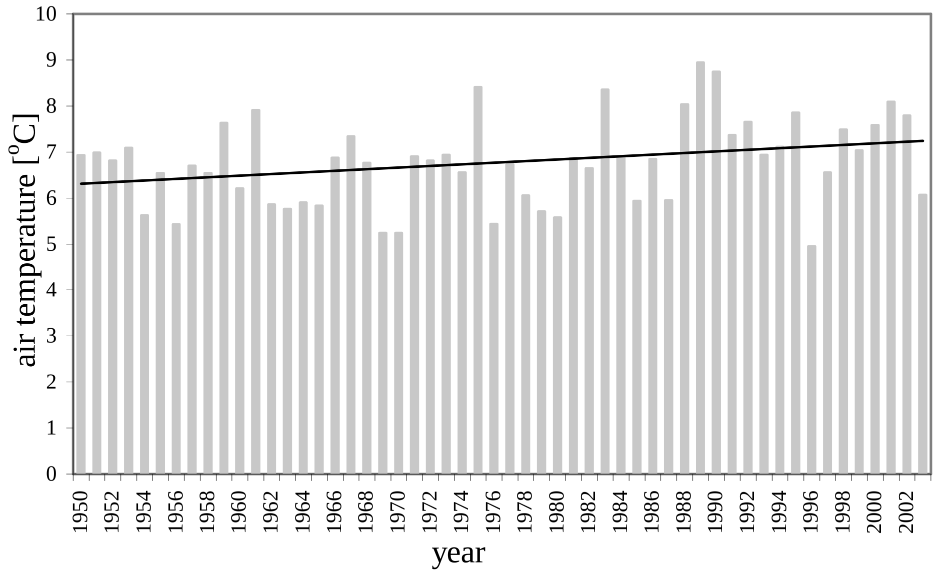

Fig. 5. Mean annual air temperature in the period 1950 – 2003.

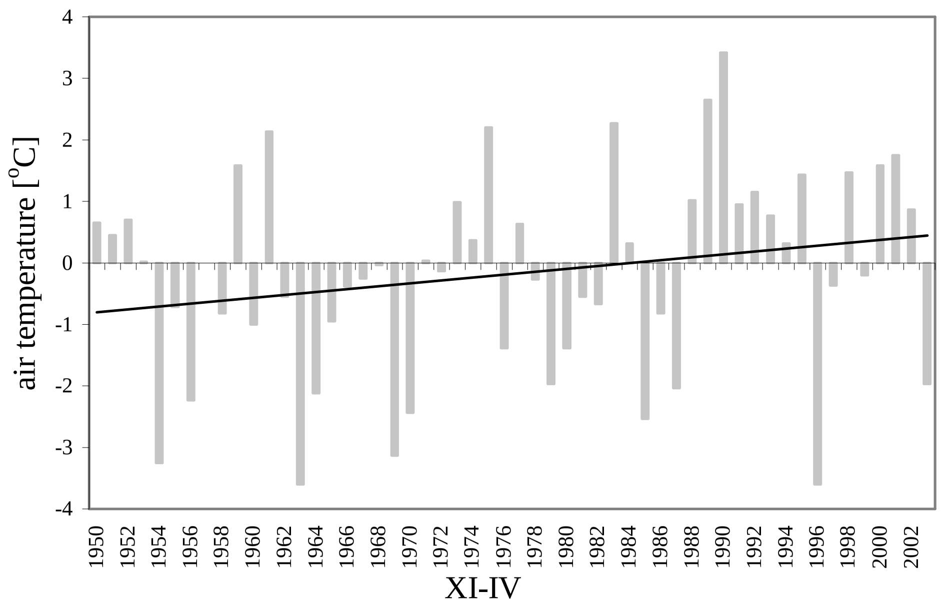

Fig. 6. Mean air temperature in the winter season (1950 – 2003).