PRACE GEOGRAFICZNE, zeszyt 108

Instytut Geografii UJ
Kraków 2000

Barbara Obrębska-Starkel

AN IMPACT OF CLIMATE IN DIFFERENT SCALES (EXEMPLIFIED BY MULTI-ANNUAL CHANGES IN ECOCLIMATE OF FOREST COMMUNITIES)

Abstract: Based on multi-year studies the author presents effects of various human impacts on the natural environment of the Polish Carpathians (deforestation, reservoir constructing etc.) and she evaluates a rate and magnitude of observed climatic changes. She emphasises the scope of information to be stored in data bases that is needed for such studies.

Key words: ecoclimate, local climate, forest communities, anthropogenic changes of climate.

1. Introduction, Aim and Scope of Study

Factors causing climatic changes – in scales from global to local – are, i.a., atmospheric circulation and income of solar radiation (Boer, de Groot 1990). Symptoms of these changes manifest in the environment as modifications of water conditions, vegetation covers and soils (Maruszczak 1988). Special attention should be focused on relation between climate and water conditions. In global and regional scales occurrence of large ecological units depends on a potential water supply for plants. In a local scale human impact results in the most significant modifications of the environment. In re-modelled habitats of former natural communities, there is succession of species that do not conform with the initial species composition.

This paper aims at presenting examples of meso- and local scale climatic changes in the Western Carpathians that have been caused by human management of forest communities in temperate cold zone (mean annual air temperature 6-4°C, 700-1150 m a.s.l.) and in temperate warm zone (8-6°C, 250-700 m a.s.l.). Characteristic features of ecoclimate are considered for: (1) the intermediate patch from *Piceetum abietetosum* to *Fagetum Carpaticum* in Ochotnica Górna in the Jaszcze valley in Gorce Mts., (2) the foothill forest *Tilio-Carpinetum* in Gaik-Brzezowa in Raba valley. The source materials comprise: hourly records of air temperature from various periods obtained by

thermographs placed in standard meteorological shelter at 200 cm above ground under tree crowns and in an open areas (Obrębska-Starklowa 1970, 1998). The record series for the Jaszcze valley covers a 3-year long period (from September 1962 to August 1965) in sites "Łąka (862 m a.s.l.) and "Las" (885 m a.s.l.). The series for Gaik-Brzezowa of 1971-1996 allows for reconstructing changes in the topoclimate structure in the medium-high foothill relief (height differences 60-200 m). These changes are induced by setting up the drink water reservoir for Cracow on the Raba river. The reservoir was filled up in 1986-1987. The paper presents multi-annual trends in air temperature in the interior of oak-hornbeam forest ("Las" – 281 m a.s.l.) and in the open area ("Zbocze" – 283 m a.s.l.).

2. Study Results – Example (1)

In the forest community in the Jaszcze valley, a tree crown layer is formed by fir and beech with an admixture of spruce (tree height 20-30 m, crown canopy compactness 70%), and brushwood layer – by fir and beech as well. The data presented in Table 1 illustrate differences in annual and diurnal courses of ecoclimatic elements between forest and open area, and allow to infer about potential changes which may appear due to deforestation.

Mean annual air temperature in sites „Łąka" (4,3°C) and „Las" (4,2°C) were almost the same, but differences are noticeable in mean monthly values. Mean temperature was higher by 0.4–0.9°C in „Łąka" than in "Las" from April to September, yet it was lower by ca. 1°C in winter season. A range of amplitudes between mean temperature of day and night was different; particularly the night temperature in the open area was by ca. 1°C lower in year at average (and in a range from –0.4 in February to –1.3°C in January and December). The smallest differences (from –0.2°C to 0.2°C) in mean diurnal temperature between "Łąka" and "Las" were characteristic of October

Tab. 1. Thermal characteristics (°C) of the air at the stations of Jaszcze- Łąka (A) and Jaszcze – Las (B) in the three year period (September 1962 – August (1965).

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
True mean diurnal air temperature													
A	–7.9	–7.7	–2.4	4.7	9.5	14.0	15.0	13.5	11.0	6.1	2.5	–6.4	4.3
B	–6.8	–7.9	–2.3	4.3	8.6	13.5	14.3	12.7	10.4	6.3	2.6	–5.3	4.2
Δ	***–1.1***	***0.2***	***–0.1***	***0.4***	***0.9***	***0.5***	***0.7***	***0.8***	***0.6***	***–0.2***	***–0.1***	***–1.1***	***0.1***
Mean air temperature at day-time													
A	–6.9	–6.3	–0.8	6.5	11.0	15.0	15.9	14.6	12.0	7.9	3.5	–5.2	5.6
B	–6.1	–7.2	–1.6	5.3	9.3	14.0	14.8	13.3	11.1	7.3	3.6	–4.8	4.9
Δ	***–0.8***	***0.9***	***0.8***	***1.2***	***1.7***	***1.0***	***1.1***	***1.3***	***0.7***	***0.6***	***–0.1***	***–0.4***	***0.7***
Mean temperature at night-time													
A	–8.6	–9.0	–3.7	2.5	6.9	11.4	12.6	11.1	8.8	4.6	1.6	7.0	2.4
B	–7.3	–8.6	–2.8	3.1	7.7	12.1	13.1	11.8	9.3	5.4	2.1	5.7	3.4
Δ	***–1.3***	***–0.4***	***–0.9***	***–0.6***	***–0.8***	***–0.7***	***–0.5***	***–0.7***	***–0.5***	***–0.8***	***–0.5***	***–1.3***	***–1.0***

and November, as well as of February and March. In the forested areas, a protective mantel of tree crown canopy delayed snow thawing during spring melting season. In relation to the open area – the snow cover was spread 100 m lower on the south-facing slopes, and 200 m lower on the north-facing slopes. Number of days: with ground frost (tmax >0°C, tmin <0°C) was larger by 27 days in "Łąka" than in "Las", with severe frost (tmin <-10°C) by 9 days, and the period without frost was shorter by 38 days. The dates of first ground frost were earlier by 3 weeks in "Łąka", while the dates of the latest ground frosts were delayed by 2.5 weeks. In the open area, at the height of ca. 850-900 m a.s.l. the period with mean diurnal temperature above 5°C was longer by 3 days, the period of an active plant development (mean diurnal temperature – tavg >10°C) was also longer even by a week, but the frequency of thawing days (tavg <0°C, tmax >0°C) was higher by 8 days than in the tree stand. In the head area of the Jaszcze stream, at the height interval from 860 m (Jaszcze – "Łąka") up to the main ridge of the Gorce massif (Turbacz, 1308 m a.s.l.) number of days with minimum air temperature inversion was almost twice as large (122) when compared with a profile Jaszcze-Las – Turbacz (66).

The structure of meso- and topoclimates in the Jaszcze valley was reflected best by wasting of the snow cover by the end of the severe and snowy of winter 1963/1964. During the thawing in forest communities (80% of the studied drainage basin) the snow cover was still thick (thickness over 50 cm, and maximum to 150 cm). Its melting on the south-facing slopes at the height 1000-1200 m a.s.l. took place by 3.5 weeks earlier than in a narrow, shaded valley bottom at the height of 750-850 m. The described process was responsible, i.a., for high extent of a forest-farmland line which is a sensitive ecotone representing extreme conditions of heat exchange and water balance in the Polish Carpathians. Deforestation in the mountains strengthens local contrasts in a pattern of thermal conditions (increase in diurnal amplitudes and annual temperatures). On the open slope surfaces gravitational descend of cool air intensifies, frequency and intensity of air temperature inversion increases as well. Moreover, forest downcutting and timber transportation add up to formation of deep furrows or gullies, increased surface runoff, outflow of water and debris from weathering covers and rapid floods in the mountains.

3. Study Results – Example (2)

The effect of setting up the water reservoir may be traced in the topoclimate structure. The examination of tendencies in changes of the foothill forest ecoclimate in Gaik-Brzezowa is based on 26-year long series of air temperature. In this period the reservoir was filled up and its area amounts to 950 ha and capacity 100 million m^3. The base station "Terasa" in the Raba valley (259 m a.s.l.) terminated its functioning in 1984. The role of this station was passed to station "Kopiec" at the flattened top part of the foothills (302 m a.s.l.) in 1981. Both the stations were operating simultaneously in 1981-1984.

In this paper the course of differences in mean air temperatures of a year and summer season in sites "Las" and "Zbocze" for a multi-year period has been examined

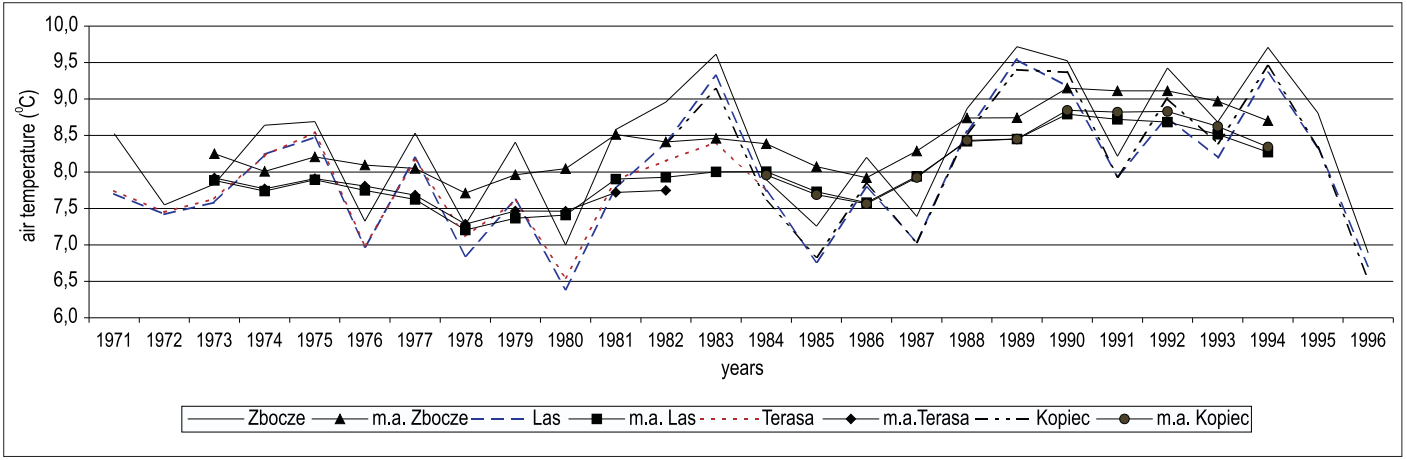

Fig.1. Mean air temperature and five-year moving averages (m.a.) at the stations: Zbocze, Las (in the period 1971-1996), Terasa (1971-1984) and Kopiec (1983-1996).

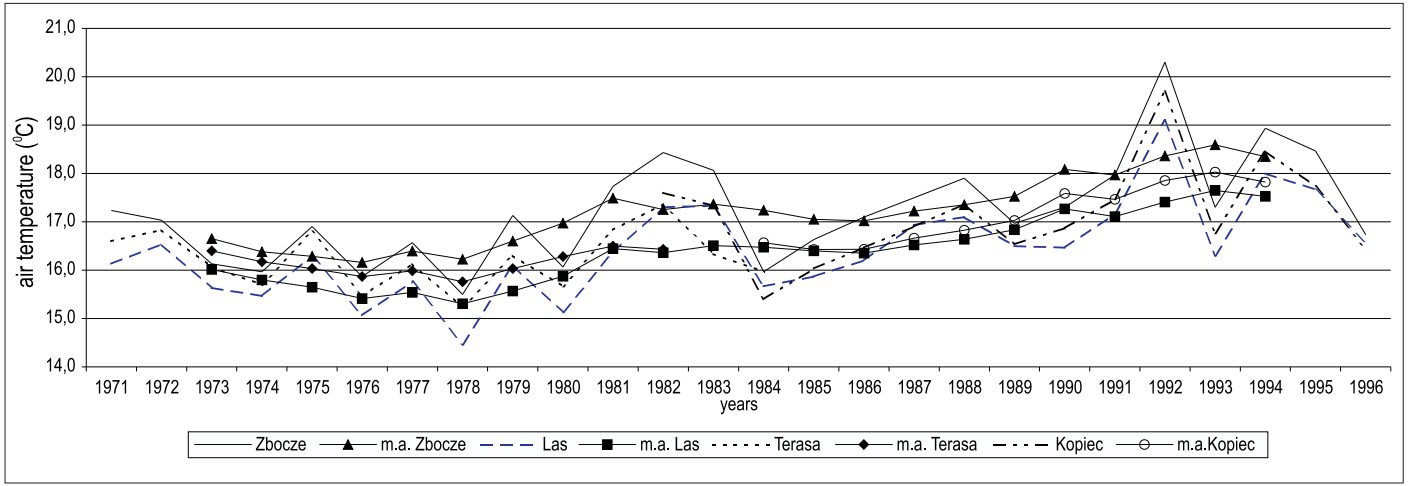

Fig.2. Mean air temperature and five-year moving averages (m.a.) in summer at the stations: Zbocze, Las (in the period 1971-1996), Terasa (1971-1984) and Kopiec (1983-1996).

with respect to the base station operating in the given sub-period. The series of air temperature had been smoothed by means of 5-year moving averages, thus fluctuations of the studied element appeared. The purpose of this paper was to show a genetic tendency in climatic changes in the regional and local scales. In 1971-1987 mean temperature on "Zbocze" was 12.2°C, in the oak-hornbeam forest 11.5°C, but after inundation of the Raba valley – 13.2°C and 12.1°C, respectively. In the entire period in site "Las" there was a slow increase in air temperature of a year and of particular seasons (cf. Fig. 1 and 2). For example, the trend value for the mean annual temperature was 0.51°C/10 years (period 1971-1996), and in summer season 0.99°C/10 years. In the examined series of the mean annual temperature it is possible to distinguish a phase of cooler years of 1973-1987 and a much warmer phase of 1988-1995 that coincides with the period of the reservoir functioning. According Brzeźniak and Limanówka (1999) the increasing trend of temperature in Poland from 1961 is in agreement with the trend of a zone circulation index (progression index after Murray and Lewis). Therefore, starting from 1988 one observes an overlapping effects of the air circulation in the regional scale and of the changes in the land use pattern in the local scale. The latter are known from the decreasing tendency in the mean annual temperature of 1988-1996 that amounts to –1.28°C/10 years and that was likely caused by the increased intensity of evapotranspiration.

Comparison of Figures 1 and 2 provides evidence that the differences in thermal characteristics for various types of the topoclimate were on a constant level in the Raba valley despite the air temperature fluctuations in the multi-year period that resulted from the changes in the atmospheric circulation. That implies the model of spatial land use pattern decides upon persistence of the topoclimate structure.

4. Conclusions

– Mountain ecosystems are very prone to climatic changes.

– Evaluation of human impact on the spatial pattern of topoclimate conditions has to be based on multi-annual field studies in typical environmental conditions.

– The "metadata" bases should include information about modifications of particular elements of the environment which are associated with various forms of land use and management.

– When considering thermal characteristics for the studies on the changes in forest communities ecoclimate special attention should be focused on extreme temperatures and on the indices derived from these temperature.

Acknowledgements

The study was supported by KBN (Polish Committee for Scientific Research), grant no 6P04G01513 entitled „Zmiany topoklimatyczne i geoekologiczne na Pogórzu Wielickim w otoczeniu dobczyckiego zbiornika wodnego" (Topoclimatic and geoecologic changes in the surrounding of the Dobczyce reservoir in Pogórze Wielickie).

References

Boer M. M, De Groot R. S. (ed.), 1990, *Landscape Ecological Impact of Climate Change*, JOSS Press, Amsterdam.

Brzeźniak E., Limanówka D., 1999, *Zmiany temperatury powietrza w Beskidzie Sądeckim w latach 1961-1990*, Probl. Zagosp. Ziem Górskich, 5-18.

Maruszczak H., 1988, *Zmiany środowiska przyrodniczego kraju w czasach historycznych*, [in:] *Przemiany środowiska geograficznego Polski*, Wszechnica PAN, Ossolineum, 109-135.

Obrębska-Starklowa B, 1970, *Mezoklimat zlewni Jaszcze i Jamne*, [in:] *Doliny potoków Jaszcze i Jamne w Gorcach, Studium przyrody, zagospodarowania i ochrony terenów górskich, Cz. II*, Medwecka-Kornaś A. (red.), 7-99.

Obrębska-Starklowa B., 1998, *Transformation of Environmental Conditions in the Carpathian Foreland Oak-Hornbeam Forest Communities Versus the Contemporary Changes in Climate*, International Scientific Conference „Forest and Water" Cracow, 25-29 May 1998, 85-95.

Barbara Obrębska-Starkel
Institute of Geography
Jagiellonian University
Cracow
Poland