The upper beech forest line in the Steneto Biosphere Reserve on the northern slopes of the Stara Planina Mts. (Central Bulgaria)

STEFAN MICHALIK

Nature and Natural Resources Protection Research Center, Polish Academy of Sciences, Lubicz 46,
31-512 Kraków, Poland

(Received: March 30, 1990. Accepted: November 23, 1990)

Abstract

The upper beech forest line has a very complicated shape in a mountain valley running in the W-E direction. On the shady northern slope it reaches an average of 1659 m above sea level, while on the insulated southern slope, about 1760 m. It was found and proven statistically that the altitude of the boundary is dependent on the relative isolation ($r = 0.309$, $\alpha = 0.01$), exposition and relief of the territory.

Key words: altitudinal vegetation belts, climatic upper beechwood line, inversion of forest belts, exposures, relative insolation, biosphere reserves, Stara Planina Mts.

INTRODUCTION

The boundary between beech and coniferous forests in the mountains of Europe has not been studied in as much detail as has the timberline (Fekete and Blatny 1914, Sokołowski 1928, Müller-Stoll 1954, Plesnik 1959, 1971, Öcologie 1967, Köstler and Mayer 1970, Grebenshchikov 1978, and many more). Its natural course has been distorted in many regions by forest exploitation and shepherding. Most frequently, the upper beechwood border has descended and its dependence on local climate, relief and edaphic conditions has been disrupted.

The author of this paper has made use of areas which have maintained their natural distribution of forest communities to carry out studies on the topography and ecology of the upper boundary of beech forests in the Western Carpathian

Mts. and Stara Planina Mts. The main objective of these studies is to determine the dependence of altitude and the course of the boundary on selected traits of local climate and relief of the terrain. An understanding of these relationships is important for forestry and ecology. It may facilitate the restoration of the natural range of beech forests in mountainous regions.

This is the third in a series of papers devoted to the Biosphere Reservation in Stara Palenina. It presents an analysis of the upper boundary of beech forests in an E-W running valley characterized by strong temperature inversions. In earlier publications we have presented this relationship within valleys and mountain ridges running generally in the north-south direction under conditions of gentle forms of relief (Michalik 1985) and for very steep and rocky terrains (Michalik 1989).

TERRAIN AND METHODS

The study was carried out in the upper part of the biosphere reserve, Steneto, in the Černý Osm River valley. This river flows out from under the Lewski Peak (2166 m above sea level). Spruce forests dominate in the upper parts of the valley (*Vaccinio-Piceion*), beechwoods in the lower (*Fagion silvaticae*). They have been subjected to intense influence of man for many hundreds of years. The only natural, or slightly affected borders between belts of beech and spruce have survived on the shady, cool and inaccessible slopes with northern exposition and on the valley floor. The slopes with southern exposition have a milder climate and were much better for shepherding. The natural forests were considerably damaged about 300 years ago by fires that were started intentionally in order to gain room for pastures. This is why these detailed studies were carried out only on northern slopes. The upper boundary of a beech forest, about 6 km long, was mapped at a scale of 1:10 000. Sixty-three measuring sites spaced approximately 100 meters apart were marked along this entire length. The following parameters were determined for each point: elevation, inclination, exposition, type of relief and relative insolation, which is a function of exposition and inclination.

RESULTS

The mean altitude of the upper beech forest on the northern slope of the studied valley (Fig. 1) was determined to be 1659 m above sea level (ASL) and exhibited a high degree of variation ranging from 1510 to 1725 m ASL. At a typically northern exposition (N) the border was on average 1633 m ASL (minimum 1510, maximum 1700 m). In other local expositions it most often ran somewhat higher (Table 1, Fig. 2), especially in a typically western (W) exposition, where the average altitude was 1706 m ASL (minimum 1690, maximum 1725 m).

Fig. 1. The boundary between the beech and spruce forest belts in the upper part of the Cerni Osm river valley: 1 — upper beech forest line (a — real, b — reconstructed); 2 — beech forest *Asperulo odoratae-Fagetum*; 3 — spruce forest *Piceetum balcanicum*; 4 — main mountain ridges; 5 — small mountain ridges; A-B — profile presented on Fig. 4

A moderately strong but significant relationship between the altitude of the upper beech forest border and relative insolation, which is a complex indicator of local climate, was found. The rise in the altitude of the boundary (y) with increasing values of relative insolation (x) is described by the regression equation: $y = 1429.66 + 2.404 x$. The correlation coefficient $r = 0.309$ ($\alpha = 0.01$).

Fig. 2. Average altitudes of the upper beech forest line at various exposures; $\bar{x}$ — mean altitude of the upper beech forest line for the studied whole area

Table 1

Significance of differences between the average altitudes of the upper beech forest line at different exposures

	n	$\bar{x}$	N 1633	NNE 1697	NNW 1645	NE 1707	NW 1632	ENE 1700	W 1706
N	32	1633	—	64	12	70	1	67	73**
NNE	8	1697		—	52	6	65	3	9
NNW	4	1645			—	58	13	55	61*
NE	4	1707				—	71	3	3
NW	4	1632					—	68	74**
ENE	5	1700						—	6
W	3	1706							—

* — $\alpha = 0.05$, ** — $\alpha = 0.01$

Table 2

Significance of differences between the average altitudes of the upper beech forest line on different morphological forms of terrain

	n	$\bar{x}$	A ₁ 1545	A ₂ 1642	B 1625	C 1697
A ₁	8	1545	—	97**	80**	152**
A ₂	5	1642		—	17	55**
B	13	1625			—	72**
C	37	1697				—

A₁ — main valley, A₂ — small valleys,

B — ridges, C — slopes

Fig. 3. Average altitudes of the upper beech forest line on various morphological forms of territory; A₁ — main valley, A₂ — small valleys, B — mountain ridges, C — slopes ($\bar{x}$ — see Fig. 2)

A very distinct dependence was found in the case of differences in the relief (Table 2, Fig. 3). The spruce forests descended most in the part of the main valley with springs which is deeply cut into the mountain. The mean altitude of the boundary between beech and spruce forests there is 1545 m ASL (minimum 1510 m, maximum 1640 m). In the significantly smaller side valleys this border runs higher and is close to the arithmetic mean for the entire studied area. The lowering of the beech forest line is much more pronounced on the mountain ridges. Its arithmetic mean is 1625 m ASL (minimum 1530 m, maximum 1670 m). This border runs highest on those slopes whose relief is least diverse. Here it averages 1698 m ASL, that is, 29 m above the mean value for the whole studied area, 80 m higher than the mean for mountain ridges and is by 152 m above the mean for the part of the main valley with springs (Table 2).

DISCUSSION

The studied valley is situated on the main ridge of the Stara Planina range. The local climate here is somewhat milder than on the slopes of this range falling towards the north where the beechwoods reach up to an average of 1600 m ASL (Grebenshchikov 1978, Velchev et al. 1982, Michalik 1985, 1989). This is why the upper boundary of the beech forest runs at a much higher altitude in the studied valley. The beechwoods probably reached a level of 1800 m ASL on the highly insolated southern slopes, but they were destroyed around 300 years ago by fire and shepherding. Their probable upper boundary was reconstructed on the basis of the regularities determined up to now (Michalik 1985, 1989, mscr.), taking into account the topography of the terrain and the remaining

fragments of beech stands and individual beech trees (see Fig. 1). The relatively high reach of the beech forests in the Steneto Reserve is typical for the mountains of the Balkan Peninsula (Grebenshchikov 1978, Velchev et al. 1982, Kochev 1983). In the Alps they reach about 1450 m ASL (Köstler and Mayer 1970, Ellenberg 1978, and many others). In the Carpathian Mts. this limit is very diverse (Fekete and Blatny 1914, Plesnik 1959, Pawłowski 1972) and ranges from about 1400 m in their southern part to about 1150 in their western one.

In all of the listed mountain ranges, very strong differentiation of the altitude of the upper boundary of the beechwoods was found depending on the exposition. In areas with gentle reliefs this dependence is more logical in nature since the increase in the reach of beechwoods occurs in agreement with the classical exposition series (N-E-W-S) from coldest to warmest (Köstler and Mayer 1970, Michalik 1985, and many others). This dependence is less pronounced in areas that are steep and rocky with the reach of the beechwoods becoming very dependent on the relief of the terrain (Michalik 1989). It drops sharply on mountain ridges, especially in deep valleys.

On the territory of the studied Steneto Reserve, in the upper part of the Černi Osm River, the phenomenon of inversion of altitudinal forest belts is found to occur. The course of the general climatic boundary of beech woods is strongly disrupted here and modified by local climate and microclimate and by the very diversified morphology of the terrain. The unfavorable influence of the local climate results in spruce forests descending to the bottom of the valley at 1510 m ASL (Figs. 1, 4). This is related mainly to the temperature inversion, flow of

Fig. 4. Inversion of altitudinal forest belts in the upper section of the Černi Osm river valley: 1 — spruce forest of the upper montane forest belt, 2 — beech forest of the lower montane forest belt

cold air masses, retention of the snow cover which shortens the vegetation period, and the high degree of shadiness. Inversion of forest belts is very characteristic of mountain valleys running east-west. Similar facts have been found in numerous valleys of the West Carpathians.

In the current study it has been found that three different types of boundaries between forest belts occur on the northern slopes of the Stara Planina. The classical microclimatic type was described in the Boatin Reserve which has gentle forms of relief (Michalik 1985). The microclimatic-orographic types was found in the Tsarichina Reservation, characterized by a very steep and rocky terrain (Michalik 1989). The boundary between the forest belts described in this paper is an example of the inversion type.

The results of the study carried out in the Stara Planina exhibit a very large degree of similarity with the typology of natural altitudinal forest belts in the Alps (Jahn 1952, Müller-Stoll 1954, Öcologie... 1967, Kostler and Mayer 1970, Ellenberg 1978, and many others) and in the Carpathians (Sokołowski 1928, Plesnik 1959, 1971, and many others).

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Górna granica lasów bukowych w rezerwacie biosfery Steneto na północnych stokach Starej Planiny (środkowa Bułgaria)

Streszczenie

W górnym odcinku doliny potoku Černi Osm, wypływającego spod szczytu Lewski (2166 m npm), skartowano przebieg górnej granicy lasów bukowych, osiągającej tu średnio 1659 m npm. Stwierdzono, że wysokość zasięgu buczyn (y) jest dodatnio skorelowana z nasłonecznieniem względnym (x). Zależność tę opisuje równanie regresji: $y = 1429.66 + 2.404x$. Współczynnik korelacji $r = 0.309$ ($\alpha = 0.01$). Wysokość górnej granicy buczyn jest także silnie uzależniona od form morfologicznych terenu. Wyraźnie obniża się w dnach dolin oraz na grzbietach. Jest to spowodowane głównie niekorzystnymi warunkami mikroklimatu i w mniejszym stopniu warunkami edaficznymi. Zmienność lokalnych ekspozycji w obrębie badanego północnego zbocza doliny miała stosunkowo niewielki wpływ na wysokość zasięgu buczyn. Na zboczu o wystawie południowej lasy zostały zniszczone przez pożary i pasterstwo, dlatego przedstawiono tylko próbę rekonstrukcji naturalnej granicy między piętrami leśnymi (por. ryc. 1) w oparciu o ogólne prawidłowości ustalone w wyniku aktualnych i wcześniejszych badań (Michalik 1985, 1989). Na badanym terenie stwierdzono wyraźną inwersję pięter roślinnych w źródłowej części doliny (por. ryc. 1, 4). Takie zjawiska są szczególnie charakterystyczne dla dolin o przebiegu E-W.