E. C. Kachaunova

Analysis of phytomass of Balkan pine *(Pinus peuce)* in communities and in separate individuals at the upper forest border in the Pirin mountains (Bulgaria)

Abstract

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The phytomass of leaves, branches and trunk of four trees of *Pinus peuce* was measured (that of leaves and branches, separately for each of three crown segments), and phytomass energy values were established. One tree grew isolated in the zone transitional between conifer belt and subalpine belt, the others were members of a stand in the conifer belt. Comparison of phytomass distribution in age classes supports the assumption that *P. peuce* is a stable and vigorous component of the upper forest belt of Mt Pirin, and has the potential of expanding its present stands upward into the transitional zone.

Introduction

The present analysis forms part of a general ecological investigation of primary biological productivity. Its object, *Pinus peuce* Griseb., is of particular interest as a tree that in places forms the upper forest border. A considerable number of publications exist on its biology, ecology and economic importance. Studies on the biological productivity, substance turnover, and edaphic requirements of *P. peuce* communities were published by Velčev & al. (1983) and Velčev & Rusakova (1985).

Pinus peuce is a Tertiary relict. During the second half of the Atlantic period it was the dominant tree species in the upper conifer belt, forming the tree line (Stefanova 1991).

So far, no study of the growth and development of *Pinus peuce* in the coniferous belt or subalpine belt has been published. The transition between these belts is critical for many species and is momentous for the formation of plant communities in the two zones. The active phytocoenotic processes of differentiation or diffusion of the vegetation, here, depend on the adaptability of the species and determine to a considerable extent the nature and altitude of the upper forest border. The biological productivity, as a fundamental property of the organisms to form organic substance, is among the most important adaptability indicators. The present paper aims at establishing the quantitative and qualitative parameters of phytomass accumulation in *P. peuce* under different conditions. Therefore, a comparison has been made between phytomass values for trees from the coniferous belt and from the zone transitional to the subalpine belt. The change of phytomass and its distribution in various fractions are presented, in relation to the different phytocoenotic role of *P. peuce* at different altitudes and under different edaphic conditions.

Climatic, edaphic and phytocoenotic conditions

The studied communities grow on a westerly slope on the right bank of the Demjanica river, between 1880 and 2500 m a.s.l., at a dip of 38°-49°. The area lies within the mountain climatic zone of the continental Mediterranean region, being characterized by an autumn to winter rainfall maximum as is typical for a Mediterranean climate. The winter temperatures are relatively high. The mean January temperature for the huts of Vihren (1970 m) and Demjanica(1895 m) is 4.7°C, the absolute minimum temperature being –17.8°C. The winter precipitation is about 300-350 mm, increasing upward and falling mostly as snow, rarely alternating with rain. Characteristic for the area are a thick snow cover (up to 180 cm) and frequent avalanches. The spring is cool, with a rainfall of about 240-300 mm. The summer again is cool, with a mean temperature of 12°C, the total rainfall being 230-280 mm. The maximum temperatures rarely exceed 20-24°C. The autumn is relatively warm and dry, with 230-250 mm of rainfall. These climatic conditions (Stanev 1991) determine a relatively short but intense vegetation period. During our investigations, which started in June 1991 and are continuing to date, considerable annual fluctuations have been observed in the seasonal development of the herbaceous vegetation, depending on the size and duration of snow cover. Similar fluctuations occur in the seasonal amount of phytomass accumulated by *Pinus peuce* throughout the year. The sampling was therefore always done in the same season, towards the end of the vegetation period, so as to ensure full comparability of the results.

The bedrock consists of intrusive granites of Palaeogene age (Gălabov 1982). The soil in the forest phytocoenoses is an umbric cambisol (Ninov 1982). The isolated, individual trees in the transitional zone above the forest grow on soils that are intermediate between the umbric cambisols of the coniferous belt and the modic cambisols of the subalpine zone above it. This is confirmed by our data on the humus and pH content of soil profiles of the studied places. The soil depth in a *Pinus peuce* phytocoenosis may reach 150 cm, in the transitional zone it is 55 cm at most. The soils are similar in mechanical composition, the fine skeleton elements dominating in the transitional zone. In the soil profile of the forest community the humus decreases with increasing depth from 39.57 % to 5.63 %, and in the transitional zone, from 21.27 % to 13.71 %. The acidity decreases with depth in both profiles, respectively from pH 5.6 to 6.4 and from pH 5.48 to 6.05.

These are favourable data for the establishment of a coniferous belt. There appears to be no obstacle to the growth of *Pinus peuce* in the transitional zone and corresponding upward shift of the forest border.

The forest community, with a canopy cover of 60 %, is comparatively old: adult trees have 100-180(-240) years of age. There is no shrub layer. Individuals of *Juniperus sibirica* Burgsd., *Pinus mugo* Turra, and *Rubus idaeus* L. do occur. In the ground layer, *Vac-*

cinium myrtillus L., *Calamagrostis arundinacea* (L.) Roth, *Moehringia pendula* (Waldst. & Kit.) Fenzl, *Geranium macrorrhizum* L. etc. predominate, with a total projective cover of c. 85 %. During sampling of a test area of 2000 m^2, 200 trees were recorded, only two of them being *Picea abies* (L.) Karsten. At places there are clearings in the tree stand. The average diameter of the trunks is 33.83 cm (max.: 78 cm), the mean height being 18-20(-30) m.

For the purposes of the investigation, a vertical transect was laid out in the transitional zone, covering a surface of 20 m × 80 m (1600 m^2). 29 trees were counted, all of them *Pinus peuce,* growing isolated or in groups. The average diameter of the trunks does not exceed 18.5 cm, with an average height of 8-10(-15) m.

Methods

To establish the amount and distribution of phytomass, the method of Molčanov & Smirnov (1967) was used, as modified by Remezov & al. (1968). Besides quantitative parameters, the energy value of each fraction was also established by burning it in a calorimeter (type KL-10, from Poland).

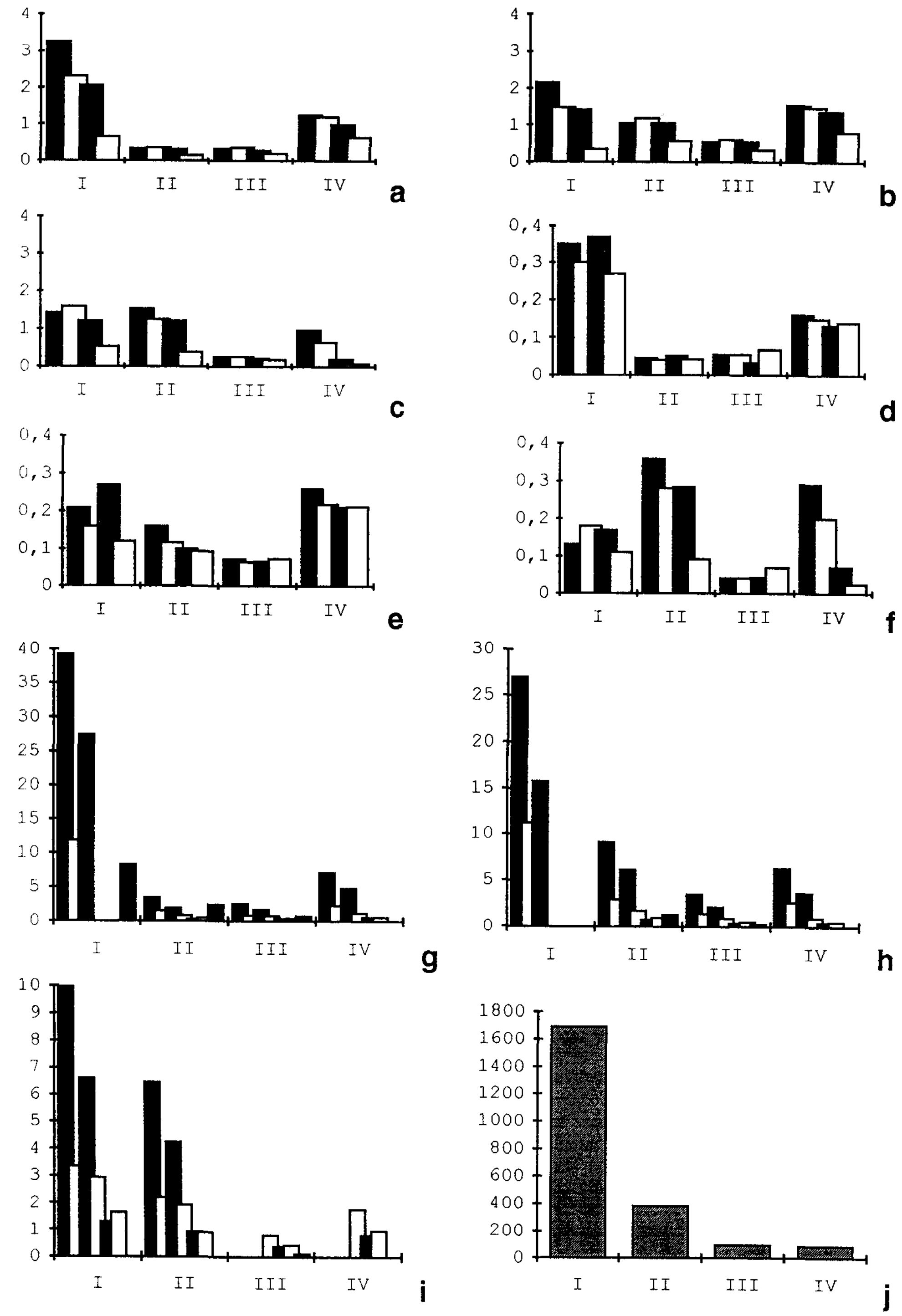
The humus amount was measured by the method of Turin, while pH was determined with the aid of a potentiometer.

Three trees (I, II and III) were felled in the forest phytocoenosis and one (IV) in the transitional zone, their parameters being as follows (d = trunk diameter at 1.3 m above the base, in cm; h = height to the top of the crown, in m; a = age, in years): I: d = 51.1; h = 30.74; a = 230; II: d = 33; h = 18; a = 162; III: d = 17.1; h = 11; a = 164; IV: d = 18.75; h = 8.5; a = 50. The crowns were separated into three equal parts, corresponding to different layers of the phytocoenosis. The phytomass was divided into fractions.

Tree I was well developed, reaching maximum dimensions and participating in the formation of the highest layer of the community (sky-line). Trees II and III were considerably lower (especially III), developing under the canopy and showing signs of depression to a varying degree.

Analysis of the phytomass

Leaves (Fig. 1a-c). – Comparison of the 1-, 2-, 3- and 4-year-old leaves shows that leaf phytomass decreases with age. This trend is consistent in the three parts of the crown in all four trees, with one exception: the phytomass of the 1-year-old leaves in the lower and middle parts of the crown of trees II and III was lower than that of the 2-year-old leaves, owing to the fact that these trees were overshadowed by others with parameters similar to those of tree I. In a general way, the leaf phytomass of trees II and III was unevenly distributed in the three parts of the crown. In the isolated tree (IV) the leaves were evenly distributed in the three parts of the crown, their amount markedly diminishing with age, because in the transitional zone, where that tree grew, depressive factors of a phytocoenotic nature are lacking. The total bulk of the assimilation apparatus in trees I and IV is similar and comparatively large, while in II and III it is considerably smaller.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Branches (Fig. 1d-i). – In general, the phytomass of the 1-, 2-, 3- and 4-year-old branches, in the four trees, decreases from the first to the fourth year, but this trend is neat only in tree IV. In trees I, II and III the phytomass of the 3-year-old branches is too high,

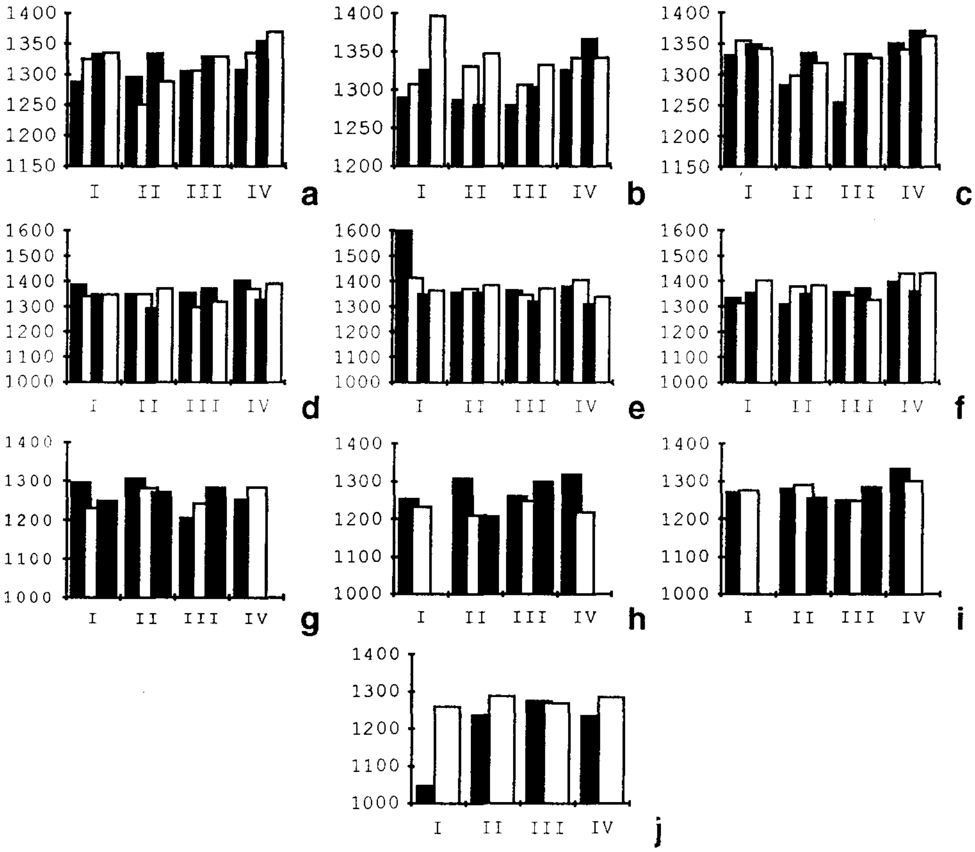

Fig. 2. Energy values of phytomass in the studied trees (I-IV), by fractions (in J/g). – **a-c,** leaves; **d-j,** branches (a, d, g, lower; b, e, h, middle; c, f, i, upper part of the crown); **j,** trunks. – In **a-f,** the 4 columns for each tree refer to age classes (from left to right: 1, 2, 3, and ≤ 4 years old); in **g-i,** the 3 columns relate, from left to right, to live branches (bark), live branches (wood), and dead branches; in **j,** the left column stands for the bark, the right one for the wood.

⇐ Fig. 1. Distribution of phytomass in the studied trees (I-IV), by fractions (absolute dry weight, in kg). – **a-c,** leaves; **d-j,** branches (a, d, g, lower; b, e, h, middle; c, f, i, upper part of the crown); **j,** total phytomass. – In **a-f,** the 4 columns for each tree refer to age classes (from left to right: 1, 2, 3, and ≤ 4 years old); in **g-i,** the 7 columns relate, from left to right, to live branches of > 2 cm diam. (total phytomass, bark only, wood only); of < 2 cm diam. (same 3 categories); and to dead branches.

which is due to the accumulation of organic substance in the 3-year-old branches, at the expense of the shed leaves (under community conditions the leaves are shed when 3-4 years old, earlier than in the open). The total phytomass of the 1-, 2-, 3- and 4-year-old branches is higher in trees I and IV than in trees II and III. The amount of living branches with a diameter of > 2 cm decreases with the decrease in trunk diameter. That fraction is unevenly distributed in all three parts of the crown. In tree I there are no branches with a diameter of < 2 cm in the lower and middle crown parts. In tree IV there are no branches with a diameter of > 2 cm in the upper part of the crown, which is due to its younger age and to the regular growth of the crown under the open conditions of the transitional zone. There are no dry branches in tree IV, and in the other trees their amount never exceeds 1.2 % of the total.

Trunks (Fig. 1j). – The phytomass amount in the tree specimens of the phytocoenosis is proportional to the trunk diameter. The phytomass amount of trees III and IV with their almost equal trunk diameter is similar, but tree III has grown to its size in 164 years, IV in only 50 years.

Energy values

Leaves (Fig. 2a-c). – The general trend is towards an increase in energy values from 1-year- to 4-year-old leaves, but it is not strictly regular. No clear differences can be observed between leaves from the three parts of each crown, or between leaves of the different trees.

Branches (Fig. 2d-i). – All branches are characterized by constant phytomass energy values, regardless of age, size and position in the crown of the four trees.

Trunks (Fig. 2j). – The energy values are similar in all trees, whether growing in the community or in isolation.

Conclusion

Our data show that differences between trees developing in a forest stand and an isolated tree are limited to the amount and distribution of the phytomass. Qualitative characteristics do not change.

This fact gives us reasons to assume that *Pinus peuce* is very stable and vigorous in the forest phytocoenosis of the coniferous belt of Mt Pirin, with a speedy and steady growth of isolated, individual trees in the zone transitional to the subalpine belt.

Under the favourable climatic, edaphic and phytocoenotic conditions prevailing in the studied region, *Pinus peuce* has the potential of extending its stands to higher altitudes.

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Address of the author:
E. Kachaunova, Institute of Botany, Bulgarian Academy of Sciences, Akad. G. Bončev str. 23, BG-1113 Sofija, Bulgaria.